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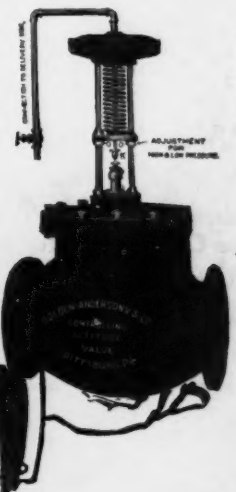

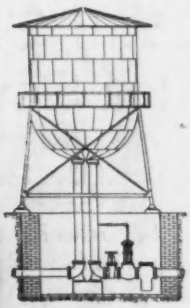

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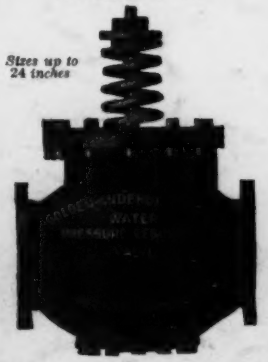

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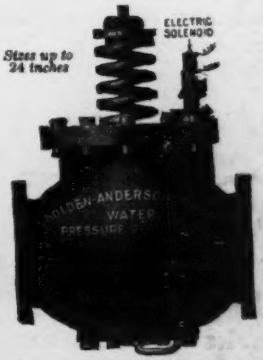

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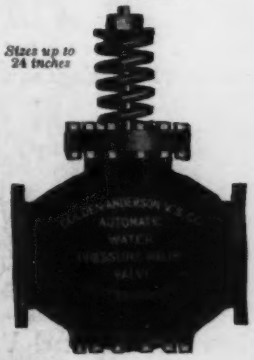

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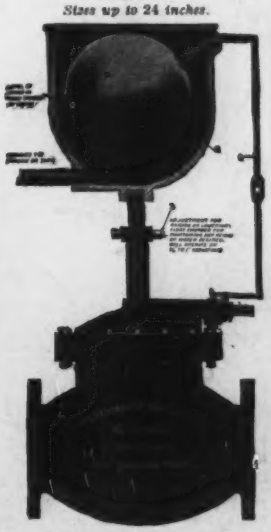

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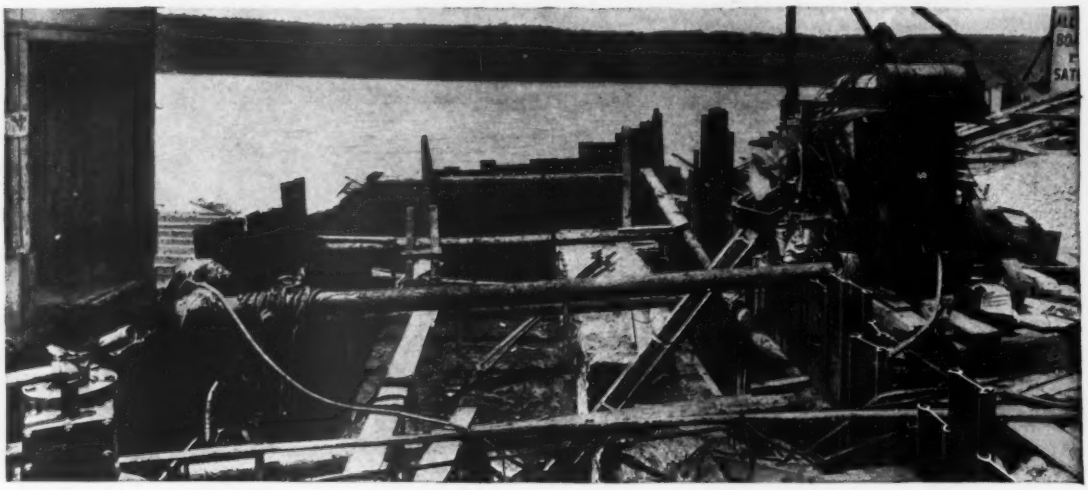

Lackawanna Steel Sheet Piling Cofferdam for an Outlet Sewer, New York City

The above 43 by 20-foot cofferdam of 12-in. Lackawanna Straight-Web Steel Sheet Piling is being utilized by the Henry E. Fox Construction Co., New York, for the construction of the outlet sewer extending into the Hudson River at the foot of Dyckman St. This steel sheet piling was driven in lengths of 18 feet and upward, the latter being required on the riverward side, which was deeper.

We are told by the contractors that this cofferdam is absolutely watertight and so satisfactory in every way that upon completion of this unit, the steel sheet piling will be pulled and reused on similar work farther down the river.

Lackawanna Steel Sheet Piling has had wide application in the rivers and harbors of New York City for such work as the above, for laying submerged gas mains, for constructing submerged portions of subways and for the construction of the largest piers (at 46th Street) in the harbor. The last named required the largest open cofferdam of steel sheet piling on record.

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Artistic Touches for Simple Water-Works Structures

Architectural treatment, or perhaps better, artistic treatment of pumping plants is a worthy subject for the water-works engineer to consider. In the early days of water-works construction, when pumping stations were designed by architects, considerable pains were taken with the ornamental features—if many old city pumping stations may be taken as examples; but since water-works operation has come more under the supervision of engineers, new structures have often been designed by engineering departments with little consideration of other than utilitarian features.

Almost every city engineering or water-works department has sooner or later to design gatehouses, auxiliary pumping stations and other small structures too unimportant to require the services or advice of an architect; yet with a little forethought such structures may be made ornaments rather than eyesores in landscapes which generally are naturally pleasing.

The accompanying view of the little pumping station of the Shrewsbury, Mass., water-supply, recently completed by the Hanscom Construction Co., engineers and contractors, Boston, Mass., is offered as an example of what may be accomplished in this way without extra expense. It is regrettable, however, that the æsthetic instincts of the designer were not followed far enough to find a way of eliminating the rather too conspicuous

ARTISTIC TREATMENT OF SMALL PUMPING PLANT; SHREWSBURY, MASS.

ARTISTIC TREATMENT OF STEEL WATER TANK: COMPLETED BELLEVUE RESERVOIR OF THE METROPOLITAN WATER-WORKS, BOSTON, MASS.

vent and exhaust pipes shown in the foreground. This pumping station is 40x20 ft. and has an interior height of 13 ft. front floor to wall plates. Concrete foundations are provided for two units of 300 gal. per min. each. The cobblestone walls are 18 in. thick, laid in 1:2 cement mortar. The mortar was mixed with one part lampblack and 5% hydrated lime. The interior face of the walls is finished with a smooth coat of cement mortar, waterproofed by the addition of hydrated lime. Window sills are dressed granite. The roof is covered with green asbestos shingles.

The second illustration shows another field for art in water-works construction, and one which has, in various instances, received considerable attention. In the case of water tanks, towers and standpipes, however, architectural treatment always means extra expense, which may or may not be justified, depending on the prominence of the structure and the neighborhood. Concrete for such structures is quite often used in the hope of increasing artistic effect at small increase of expense, and the hope is sometimes realized.

The 2,500,000-gal. steel tank on Bellevue hill, in the West Roxbury district of Boston, is perhaps the last word in this branch of hydraulic architecture. The work of inclosing this structure in granite masonry was described in *Engineering News*, Jan. 20, 1916. Since then the granite covering has been cleaned by sand blast and the adjoining observatory has been removed, so that the granite cylinder with its conical roof is now the most prominent and pleasing feature in the landscape.

The late Dexter Bracket was chief engineer of the Metropolitan Water-Works when this tank was designed and the work begun. It was finished under the direction of the present chief engineer, William E. Foss.

Asphalt Paving History

Were the average paving engineer asked the origin of the present method of constructing bituminous macadam pavements—a layer of macadam coated with hot asphalt, a layer of stone chips rolled in, another coating of hot asphalt (seal coat) and a surfacing of screenings rolled in—it is pretty safe to assume that he would say it was of very recent date, probably not more than ten years old, anyway. An engineering antiquarian finds the following item in the *Journal* of the American Institute, March, 1839. No record can be found of the effect of the communication on the Common Council.

Mr. Walter, architect, just returned from Europe, has addressed a letter to the committee of the Philadelphia Common Council on the subject of pavements. . . . Mr. Walter presents an interesting paper on the use of asphaltum pavements, which have only been recently introduced in Europe for carriageways. About 80,000 ft. have been made on a road to Versailles and in several courtyards.

Two experiments made in Liverpool, England, are thus described by Mr. Walter: The first consisted in making an ordinary M'Adamized road having its surface regulated about one inch below the intended finish of the street. This surface was then covered with asphalte in semi-fluid state and before the material had time to cool a layer of finely broken stone was strewed over it and brought to an even surface by means of a large iron roller. Another thin coat of asphalte was then put on and the surface covered with fine gravel stone, well sifted and washed, after which it was again rolled. This unquestionably makes a beautiful road and there can be no doubt of its durability.

Here, then, is an asphaltic macadam road constructed by the most approved modern methods more than three-quarters of a century ago. It would be interesting to determine if during the latter part of that 78 years a pavement of this type had been patented in our own United States.

Melte Snow Supplies Water to Arid District

Supplying arid desert land with water obtained from the melting snows of a neighboring mountain range and stored in old volcanic craters utilized as reservoirs is an interesting engineering work now being carried out in Arizona. The district to be served is in Coconino County, and extends nearly 50 mi. south from the Grand Cañon of the Colorado. The Atchison, Topeka & Santa Fe crosses it (east and west) about 50 mi. from the cañon. The country is almost entirely waterless, except for a light rainfall averaging only 10 in. per year. It is good grazing country, except for scarcity of water.

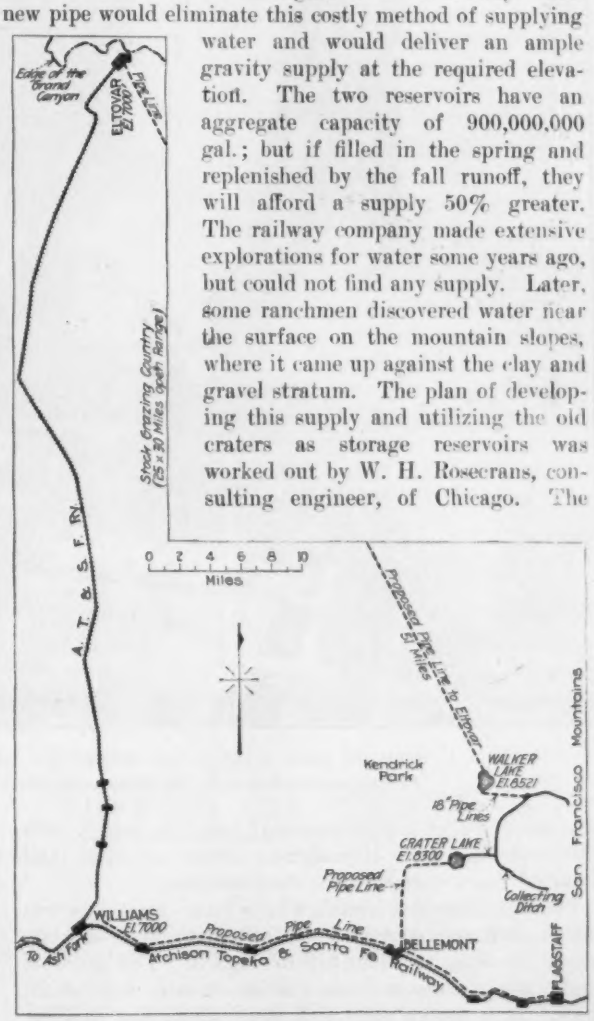
To the east of this district is San Francisco Mountain, whose slopes are heavily timbered below timber line and whose summit is about 12,000 ft. above sea level. It is always covered with snow, but the water flowing down its slopes is lost in the deep beds of light soil which form the plains. At an elevation of about 8,500 ft., however, an impermeable stratum of clay and cemented gravel approaches the surface, and here a collecting ditch has been excavated to intercept the flow, the bottom being in the impermeable stratum. This ditch is about a mile in length and has branches at elevations of 8,650 to 8,800 ft. It is 4 ft. wide on the bottom, 4 to 6 ft. deep, with a slope of 2 on 1 for the upper, or mountain, side and 1½ on 1 for the lower side. The excavated material is thrown out on the lower side. A larger ditch 8 to 12 ft. deep, of about the same length, will extend around the northern slope. The drainage area serving these ditches is about 12,000 acres on the west and 6,000 acres on the northwest side of the mountain. The annual precipitation on this area is 36 in., with 33% runoff, occurring mainly in the spring. The three months of spring, therefore, would give a runoff of 4,000 acre-ft. and 2,000 acre-ft. for the two sides, or about 1,960,000,000 gal. in all.

Within about a mile from the ditch is Crater Lake, an old volcanic crater, which normally has a little water. It was decided to utilize this as a reservoir, and a pipe line 13,000 ft. long was laid to it from the collecting ditch. This is of 8-in. sheet-iron pipe in 20-ft. lengths, with beaded joints. Each length of pipe has a bead, or ridge, stamped around each end. The end of one pipe is heated in a mixed gasoline and coal-oil furnace so that it will slip over the adjacent pipe, its hollow bead fitting over the ridge of the other, so that when cool the pipes are locked together. This pipe is made by the Western Pipe and Steel Co., of Los Angeles, Calif. The pipe line is about 2 ft. below the surface.

The lip of the crater rises 50 ft. above the surrounding ground, and the pipe line is in effect an inverted siphon. There is an outlet tunnel from the crater reservoir. This is 600 ft. long, 4x6-ft. section, and is driven through clay, volcanic ash and basalt. The crater is 2,000 ft. in circumference and 60 ft. deep, forming a reservoir of about 280,000,000 gal. capacity at 8,300-ft. elevation. The flow in the ditch was about 22 ft. per sec. until the reservoir was filled, this being completed (after 90 days' flow) in May, 1916.

From this reservoir it is proposed to lay a pipe line to Bellemont (9 mi.) and then along the railway east to Flagstaff (12 mi.) and west to Williams (20 mi.). Besides the towns and the railway there will be numerous ranches to be supplied.

A further development of the project provides for another 18-in. pipe line, 6 mi. long, to Walker Lake (El. 8,521). This is another but larger crater, 100 ft. deep, with a capacity of about 640,000,000 gal. at 8,400-ft. elevation. From this a supply pipe line is proposed to El Tovar (at the Grand Cañon), about 50 mi. This resort has a large number of tourists and employees, and the railway company has to haul in water by tank-cars for the supply of the hotel, station and grounds and also for the locomotives and cars. This water is brought nearly 100 mi. either from Del Rio or Flagstaff. The cars deliver the water into a track pit from which it has to be pumped to an elevation about 100 ft. higher than the railway. The new pipe would eliminate this costly method of supplying water and would deliver an ample gravity supply at the required elevation. The two reservoirs have an aggregate capacity of 900,000,000 gal.; but if filled in the spring and replenished by the fall runoff, they will afford a supply 50% greater. The railway company made extensive explorations for water some years ago, but could not find any supply. Later, some ranchmen discovered water near the surface on the mountain slopes, where it came up against the clay and gravel stratum. The plan of developing this supply and utilizing the old craters as storage reservoirs was worked out by W. H. Rosecrans, consulting engineer, of Chicago. The



PLAN OF WATER-STORAGE AND DISTRIBUTION SYSTEM FOR AN ARID DISTRICT IN ARIZONA

work is being carried out under his direction for Charles H. Spencer and Herbert A. Parkyn, of Chicago.

The work is being done on day-labor account, with about 30 men and teams on the ditch excavation and about the same outfit on the pipe line. The pipes are hauled to the site on wagons and handled by derricks at the trench. At present the Crater Lake reservoir has been filled, at a cost of about $50,000. Work is in progress for the Walker Lake reservoir, which will cost about $20,000, and this will be filled in the fall. The cost of the pipe line to Williams and Flagstaff is estimated at $50,000 and that of the line to El Tovar at $130,000.

Railway Terminal Built Over Large Drainage Channel

By Charles C. Hurlbut*

The Lehigh Valley passenger terminal, now nearing completion at Buffalo, N. Y., is built over a large drainage channel, the case being somewhat similar to that of the Werder building, which was built over a railway tunnel in Pittsburgh, as described in *Engineering News* of June 8. The Lehigh terminal has four stories with self-supporting walls of limestone ashlar and brick, and fireproof floors supported on steel columns.

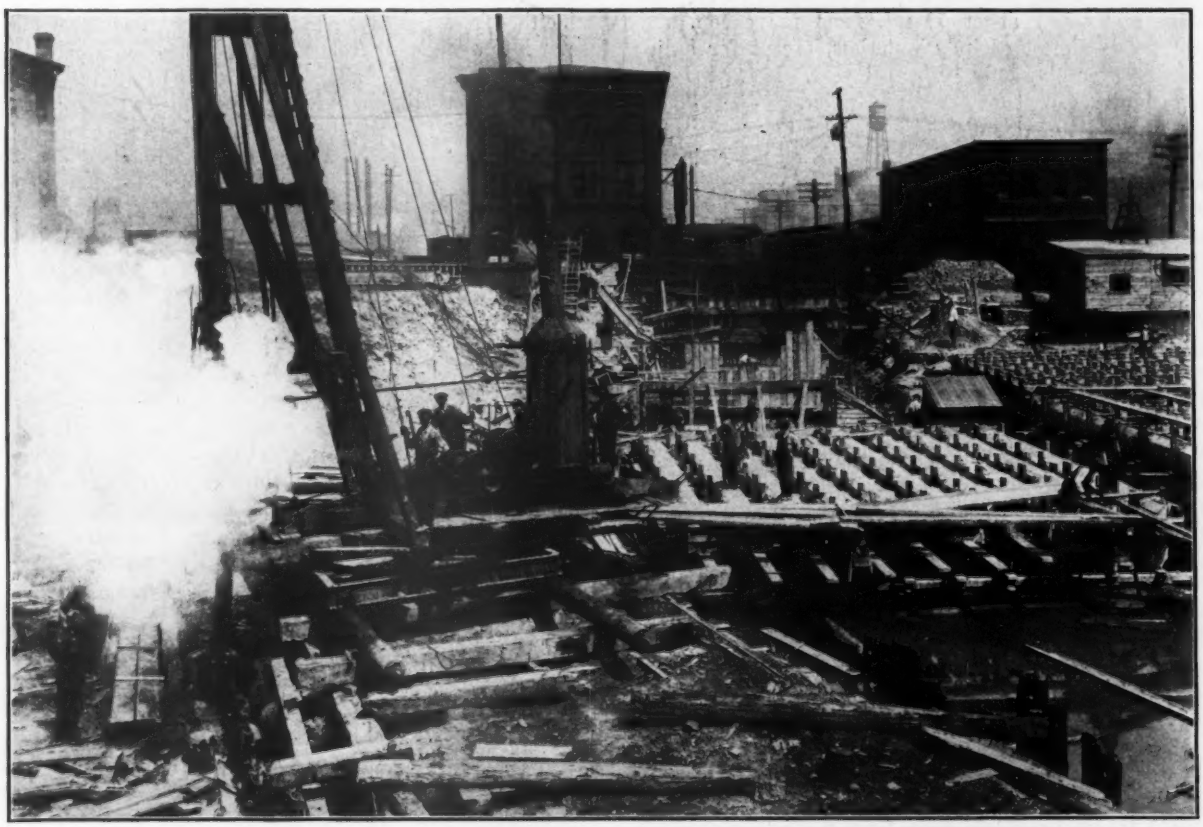


FIG. 1. SITE OF NEW PASSENGER TERMINAL OF THE LEHIGH VALLEY R.R. AT BUFFALO, N. Y.
Photograph taken July 15, 1916; sheetpiling in place and concrete piles in their forms

The old Hamburg canal, which some years ago was roofed over and converted into a sewer, flows directly across the site, as indicated in Fig. 3. The sewer is 16 ft. wide inside and has rubble masonry walls 6 ft. thick. It is roofed over with steel beams and concrete and supported on a floor of concrete laid on a stone bed. Two walls of the building cross the sewer and several of the interior columns are located over it. The top of the sewer is level with the basement floor, being about 10 ft. below the surface of the ground.

Owing to the very poor workmanship of the sewer walls (Fig. 2) and the poor quality of the ground, it was deemed inadvisable to put any additional load on the construction. The building itself is founded on concrete piles driven to rock and the expedient was adopted of building concrete piers on piles as close to the sewer walls as possible and spanning the sewer with heavy steel girders. The latter are placed on the lines of columns, which cross the sewer diagonally 18 ft. on centers and support the walls, floors and columns of the building. The girders which support the columns are 7 ft. 8½ in. deep (back to back of flange angles) while those which support only floors are 4 ft. ½ in. The girders are all set flush on the bottom a few inches above the top of the sewer, and the bottom flanges support reinforced-concrete slabs. The first floor-beams and the columns rest on the tops of the girders. In the case of the shallow girders there is a strut under the ends of each pair of beams.

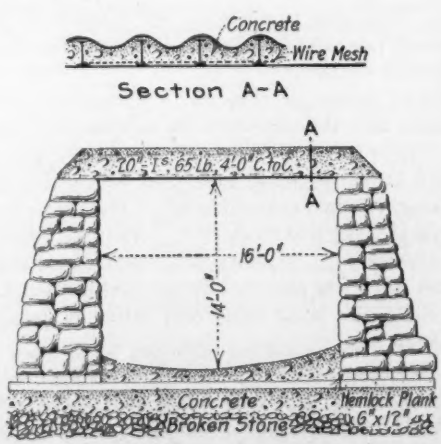


FIG. 2. CROSS-SECTION OF HAMBURG SEWER, BUFFALO, N. Y.

*With Kenneth M. Murchison, Architects Building, New York City.

The rubble walls of the sewer are porous and the water passes through them freely. As the top of the tunnel is below the high-water level of the Buffalo River, into which it flows, it was necessary to waterproof the cellar floor against a head of several feet. This was done with 6-ply tar and felt, which was secured against upward pressure by reinforced-concrete slabs spanning between the bottom flanges of the plate girders and held down by brick casing. The waterproofing and reinforced-concrete slab construction extends over the entire basement floor as well as over the sewer, but in the other parts of the building the reinforcement is laid diagonally and is held down by the brick column casing. Before driving any piles a sheeted exploration pit was sunk close to the sewer. The condition of the sewer wall and the unstable condition of the ground under it, made it seem unsafe to drive piles close to the wall as was originally contemplated, especially as the piles were to be jetted. It was therefore decided to isolate the sewer section, which was done by driving steel sheetpiling on both sides of the sewer. The piling was driven as close as possible to the bed of riprap underlying the sewer, without disturbing the riprap. Considerable difficulty was experienced in driving the sheeting and also the piles. The line of the sewer foundation was somewhat irregular and had to be felt out. In some places the line of sheeting was interrupted by obstructions and the location of pile groups had to be shifted. The main obstruction undoubtedly was the remains of the original canal wall, and this gave trouble. As it would have been difficult to remove this ruin, the locations of some of the piers were shifted to suit the conditions. Consequently, the girders could not be ordered until the piles were in place and in some cases several feet had to be added to the length of the girders. The length as built varied from 42 ft. 6 in. to 44 ft. 3 in. Three of the stone portico columns, which are 4½ ft. in diameter, came over the sewer. Instead of on plate girders, these were supported on three 30-in. 180-lb. girder beams 42½ ft. long.

The work was carried out under the direction of E. B. Ashby, Chief Engineer of the Lehigh Valley R.R., assisted by F. E. Schall, Bridge Engineer. The architect of the building was Kenneth M. Murchison, of New York City. The steelwork and foundations were designed in the architect's office by the writer. The contractor was J. Henry Miller, Inc., of Baltimore, Md.

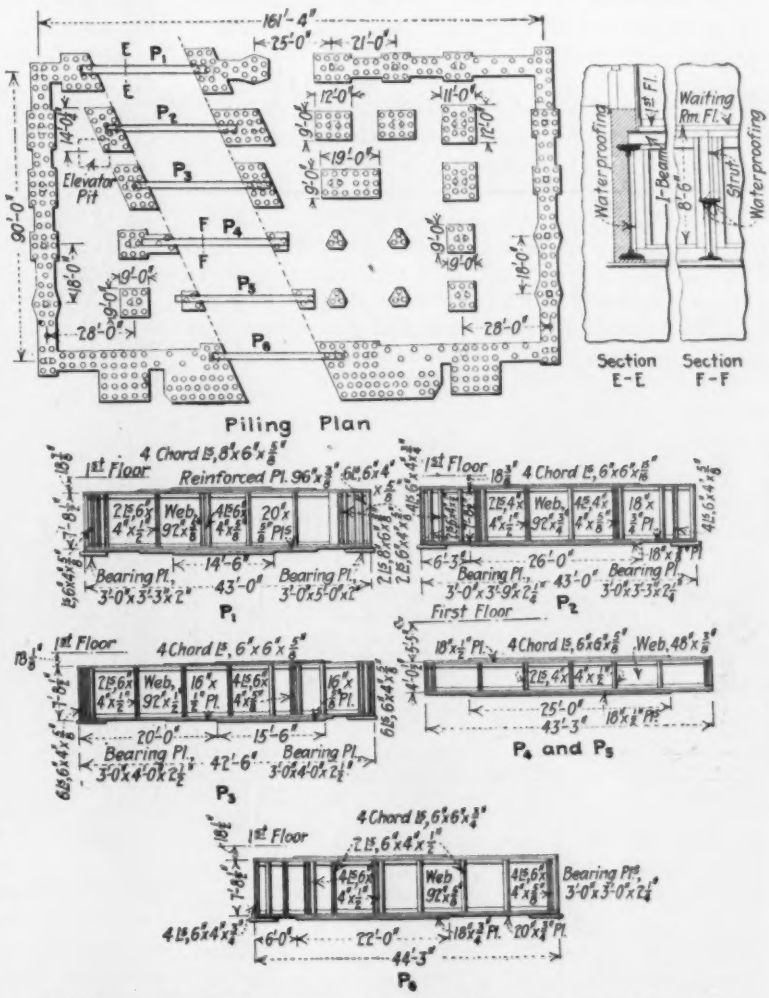


FIG. 3. PLAN OF LEHIGH VALLEY STATION, SHOWING METHOD OF DISTRIBUTING LOAD OVER LARGE COVERED CANAL

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The Output of Liquid Chlorine in the United States in 1914 was 12,217,000 lb., valued at $472,836, according to the United States Census Bureau. It was made at seven plants, of which three were located in New York, two in Michigan and one each in Illinois and Georgia.

Registering Kicks at the City Engineer's Office

The Alton (Ill.) *Telegraph* heads an article, "The City Kicking Post: An Observer Thinks the Engineering Department Has Much to Do to Keep Temper," and summarizes the observations of a citizen, who has been in the office of the city engineer frequently, as follows:

If you've got a kick a-coming, go thither without fear, and make the kick a lusty one—at the City Engineer. No matter what it is about, or if as mud as clear, the man to blame and cuss a few is the City Engineer.

According to a citizen, the City Engineer's office appears to be the official kick-receiving bureau of the city, and many of the complaints made have no more to do with the Engineer's office than Teddy Roosevelt just now has to do with the Bull Moose.

They kick about neighborhood disputes as to line fences; about chickens running at large; about catchbasins catching everything but overflow water; about telephone poles being plastered with election posters; about the river water getting muddy when it should be clear.

If a neighborhood has too many dogs and the dogs have too many fleas and the fleas have the wanderlust and leap savagely upon human beings, why should not the City Engineer be blamed for it? The dogs ought to be chained up, and the Engineer uses chains in his business; the fleas ought to be impressed some way that they must not go beyond the "dead-line" fixed by the City Engineer. The City Engineer should be the one to remedy any existing wrong or cause of complaint.

Chlorinating the Water-Supply of Greater New York

By T. D. L. Coffin*

SYNOPSIS—The largest chlorine-control plant in the world is that used for the water-supply of the City of New York. Use of multiple-unit equipment and duplicate lines; details of injection apparatus. Daily output 1½ tons of chlorine per day—for 400 million gallons of water. Control within 1% of desired quantities. Bacterial reduction to 12 per c.c.; B. coli in only 10% of 10-c.c. samples.

Besides being the largest installation of liquid chlorine control apparatus in the world, the Dunwoodie chlorinating plant of the New York City Department of Water Supply, Gas and Electricity is of unusual interest because of novel methods of application and the arrangement of duplicate apparatus and distributing lines. Installed to treat a maximum of 400,000,000 gal. of water daily

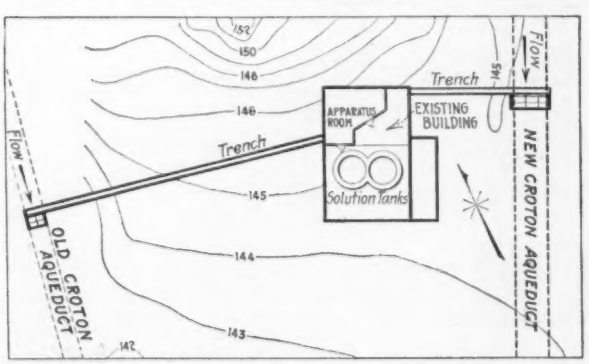


FIG. 1. LAYOUT OF DUNWOODIE CHLORINATING PLANT

flowing through the old and new Croton aqueducts this plant has a total output capacity of a ton and a half of chlorine per 24 hr.

In 1911 the advisability of installing some means of water purification to offset a possible pollution of the Croton supply was evident and a plant to apply calcium hypochlorite as a sterilizing agent was erected at the Croton Gate House. This plant was subsequently moved to shaft No. 9 on the new aqueduct and then to Dunwoodie, New York, where a permanent building was erected, provision being made for applying the sterilizing chemical to both the new and the old aqueducts from the same structure.[1] The marked increase in the price of hypochlorite, during the late summer and fall of 1915, suggested the necessity of installing a liquid chlorine plant, as under the conditions then existing a saving in the cost of operation would result and a shortage of either material would not prevent the treatment of the Croton supply. Contract for the necessary apparatus and accessories was awarded to Wallace & Tiernan Co., Inc., of New York City. In planning the equipment consideration was given to the construction of special apparatus with capacity much greater than the standard chlorinator. It was decided, however, to install the manufacturer's standard equipment so that any repair or renewal parts required could be taken from stock and avoid the necessity of carrying a supply of special parts just for this installation.

The problem was presented of having one set of apparatus for the new aqueduct, a second set for the old aqueduct and reserve units so connected that they could be used either on the new or old aqueduct as required. The whole installation was to be in duplicate to eliminate any interruption in the flow of chlorine.

The existing hypochlorite house at Dunwoodie presented an excellent location for the chlorinators and nine manually controlled direct-feed units were installed. Each unit has a maximum capacity of 325 lb. of chlorine per 24 hr. One unit is normally in service for the old aqueduct, five units in service for the new aqueduct and the remaining three are held in reserve, the distributing lines being so arranged that they are applicable to either aqueduct as required. The chlorinators, being built on the unit system, are interchangeable and can be transferred from one location to another simply by removing the supporting screws. In order to feed the required amount of chlorine without too rapid withdrawal from the chlorine cylinders and the consequent refrigeration and resulting drop in pressure of the gas, manifolds were provided for connecting ten cylinders of chlorine to each apparatus.

Each apparatus was provided with a separate check valve to maintain constant back pressure and uniform

*Assistant Engineer, New York Department of Water Supply, Gas and Electricity, Katonah, N. Y.

[1]Described by the author in "Engineering News," Feb. 27, 1913.

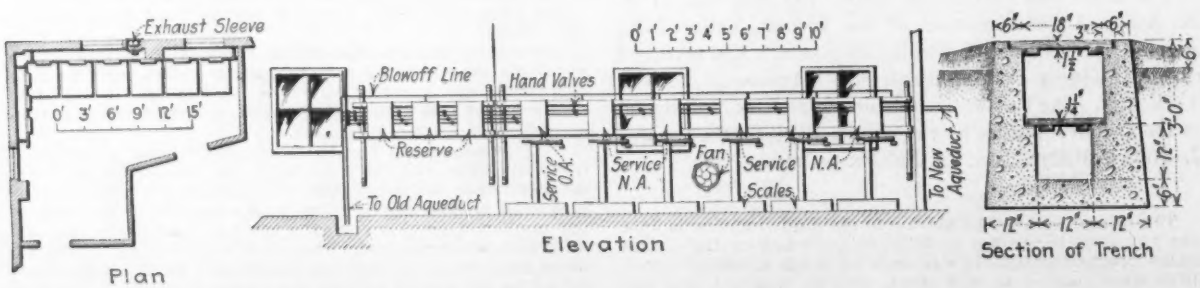


FIG. 2. APPARATUS ROOM AND PIPE TRENCH AT DUNWOODIE PLANT

density of the chlorine, and these valves were fastened directly to the apparatus panel. The usual procedure of having one check valve for each distributing line would not have been sufficient for the Dunwoodie installation on account of the large volumes of chlorine required. The accompanying sketches and views indicate the arrangement of the different units and show the distributing lines and valves and cross connections. There is a common blowoff or "chlorine relief line" to which each unit is connected.

The chlorine is conducted from the apparatus room to the aqueducts through ¾-in. extra-heavy galvanized iron pipe, the lines being in duplicate, passing through a concrete pipe vault as indicated. This arrangement of duplicate lines, readily accessible, is a further safeguard against any enforced interruption in the flow of chlorine. The lines were laid with extra-heavy fittings and litharged joints, and were tested with chlorine under pressure at frequent intervals during construction. In each aqueduct spacious concrete manholes were constructed at the end of the pipe trenches. Heavy iron covers were provided, with substantial locks to close the openings.

Chlorine diffusors, composed of a special carborundum sponge in an earthenware casing, were used to apply the chlorine to the water. Forty-five of these diffusors are in continuous service in the new aqueduct and ten in the old. The necessity of holding the diffusors rigidly in place to withstand the very considerable velocity of water, and at the same time to provide means for the ready removal of a defective diffusor without interrupting the flow of chlorine called for unique features of design. The drawings presented herewith indicate the adopted arrangement. The diffusors, ranged across the aqueduct at the invert, give a very complete mixture of the chlorine with the water, eliminating all necessity for baffles.

In the new aqueduct three grids, each holding 15 diffusors, were installed. The grids were made of 1½x¼-in. black iron with a yoke of 2x⅜-in. and a pulling bar of 1-in. square black iron, galvanized after assembly.

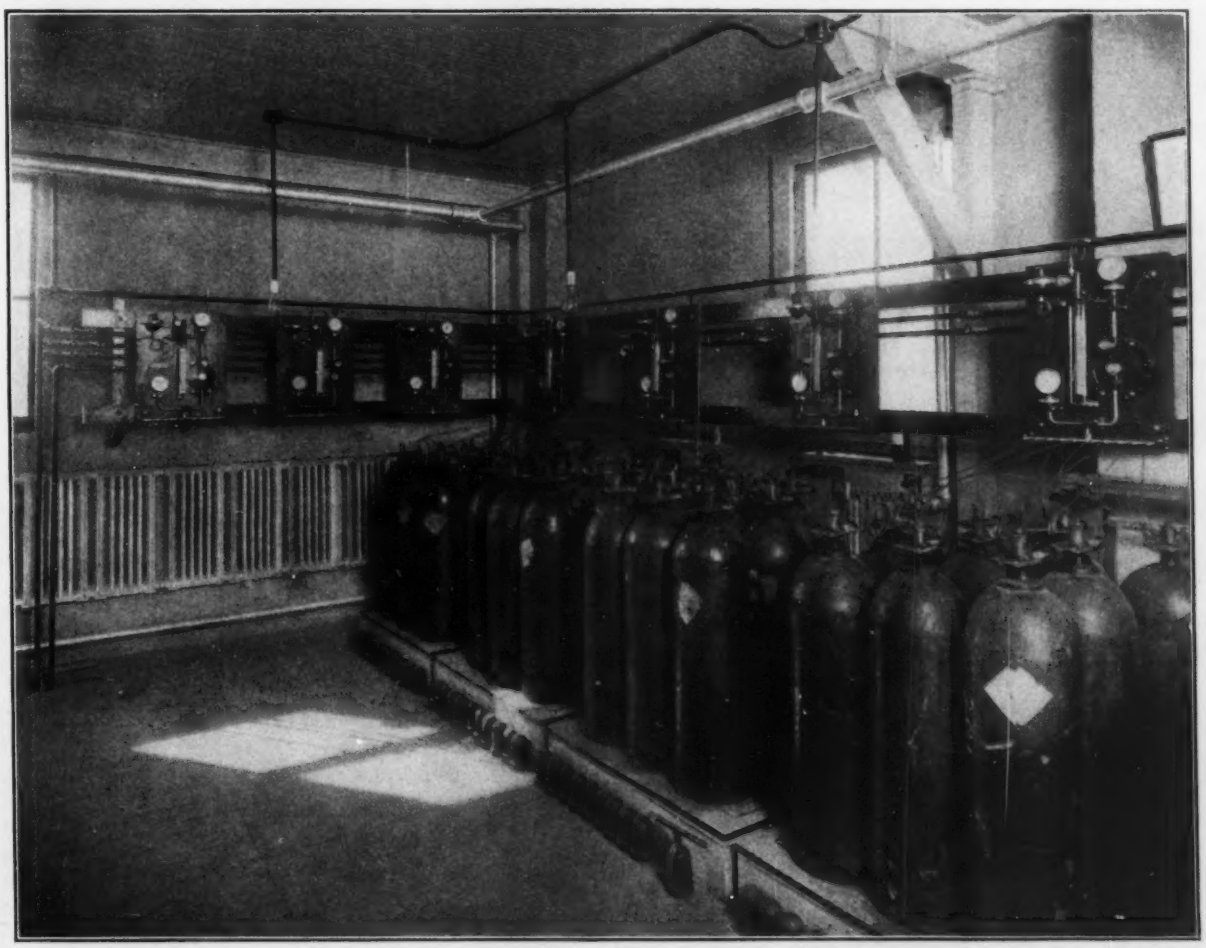


FIG. 3. INTERIOR OF DUNWOODIE APPARATUS ROOM

Each yoke is fitted with a 2-in. bronze roller 1 in. thick which slides on a 3x1-in. black-iron bar set with least dimension exposed to the current. These bars are fastened at the base in the concrete foundation of the aqueduct and are rigidly held in the concrete manhole at the top, thus serving as guides for the diffusor grids. To the pulling bars ¾-in. extra-heavy galvanized iron pipe is fastened by a ¾-in. union and serves both as a rod to pull up the grids and as a protection for the silver chlorine-distributing tubing. This construction may be seen from Fig. 3.

From the galvanized distributing lines in the manholes the chlorine passes through auxiliary valves into ¼-in. silver tubing which is threaded through the vertical pipe

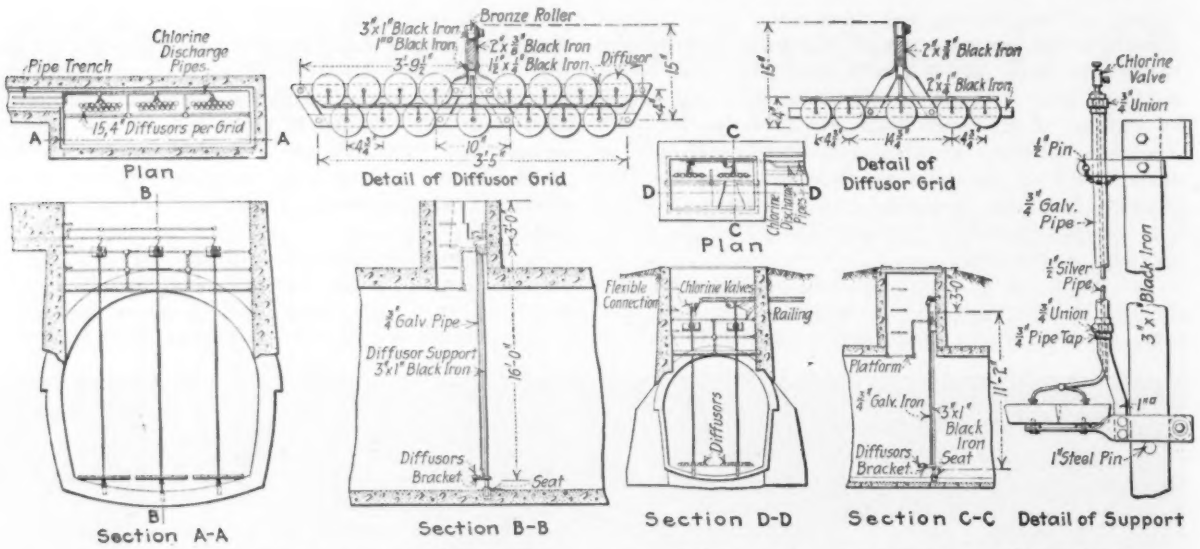


FIG. 4. DETAILS OF DIFFUSOR ARRANGEMENT AT DUNWOODIE, N. Y.

rods supporting the grids. At the grid the ¼-in. tubing connects with a manifold of $\frac{3}{16}$-in. silver tubing, there being one connection to each diffusor. At the top of each pipe rod is a valve controlling the flow of gas to the attached grid and these valves are connected by flexible tubing to shut off valves in the galvanized distributing lines. In this manner any grid can be instantly cut out of service or connected to either gas line as desired. Normally all three grids are in service. The multiple valves and connections make it possible to shut off a grid, draw it up to the manhole platform and make such examinations or adjustments as may be required, continuing the application of gas during this period through the other two grids. Fig. 4 shows the arrangement with the diffusors withdrawn for examination at the manhole platform. The arrangement in the old aqueduct is similar, but on a smaller scale—only two grids of five diffusors each being in service.

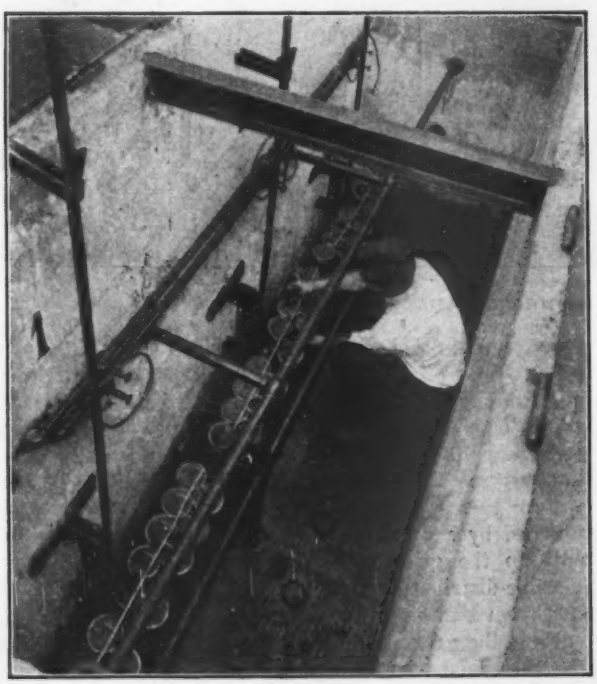


FIG. 5. DIFFUSOR GRIDS RAISED, NEW AQUEDUCT

The apparatus room is constructed of ⅞x3½-in. tongued-and-grooved yellow pine on 2x4-in. spruce studs and is 24 ft. 6 in. long and 20 ft. 9 in. wide, constructed with ceiling, and is entirely within the former hypochlorite house. It is heated by a hot water heating system and lighted by 110-volt alternating current. Ample storage capacity is provided for heating the cylinders prior to service. Six platform scales, with platforms 41x32 in., each with capacity for ten cylinders of gas are provided to check up the delivery of the chlorinators. The booth is fitted with a 14-in. disk fan driven by a 220-volt motor, discharging to the outer air and controlled by a switch outside of the booth so that the apparatus room can be readily ventilated.

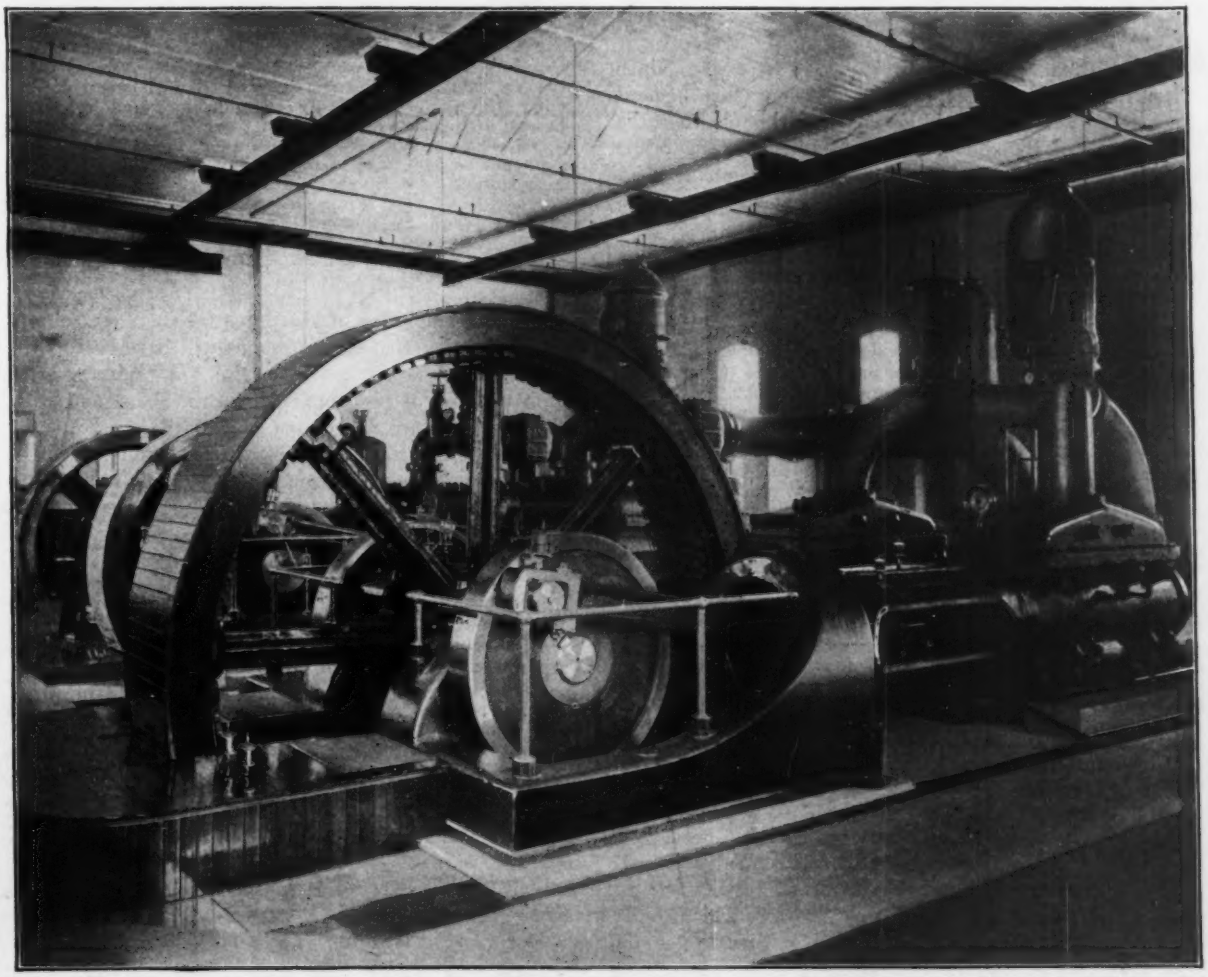
The installation has been in service since Apr. 4, 1916. The apparatus was guaranteed to deliver within 5% of the indicated weight of chlorine. On actual test it was found to have less than 1% error. Between the dates of Apr. 4 and June 30, the newly installed liquid chlorine plant has treated 29,541 million gallons, using 48,590 lb. of liquid chlorine or slightly less than 0.20 parts per million of chlorine. The water after treatment has averaged 12 bacteria per cubic centimeter as determined upon gelatine plates at 37° C. and B. coli has been absent in the 0.10-c.c. and 1.0-c.c. samples, and present in only 10% of the 10.0-c.c. samples. The apparatus was installed under the direction of Merritt H. Smith, Chief Engineer, and T. C. Culyer, Engineer, Watersheds Division, acting for the Bureau of Water Supply. C. F. Wallace directed the installation for Wallace & Tiernan Co., Allan M. E. Johnstone being the resident engineer.

Construction Material in South America—The Bureau of Foreign and Domestic Commerce of the Department of Commerce and Labor is sending William W. Ewing, M. Am. Soc. C. E., to visit the principal cities of the United States for the purpose of conferring with manufacturers of construction materials and machinery. This work is in preparation for an exhaustive report on the markets for these products in South America, and Mr. Ewing after talking with the American manufacturers will make a tour of all the southern republics for a thorough study of conditions in this branch of trade.

Pumping Six Million Gallons Daily by Water Power

The City of Lewiston, Maine, about 40 mi. north of Portland, has one of the most interesting water-works pumping stations in New England. This plant is probably one of the largest all-water-power pumping stations in the country. The average daily pumpage is 6,000,000 gal., but the plant has a capacity of about double this amount.

The city is on the Androscoggin River, which furnishes water power for practically all the manufacturing industries of a city of 30,000. The water rights are controlled by the Union Water Power Co., from which the city purchased, several years ago, 600 hp. The wheels are 15 ft. below the level of the power canal and have draft tubes of 10 ft., making a total head of 25 ft.



WATER-WORKS PUMPING STATION, LEWISTON, MAINE

The original plant was built in 1878 and consisted of two Worthington duplex pumps of 3,000,000 gal. daily capacity each, driven at 14 to 16 r.p.m. by Risden turbines. Subsequently a 3,000,000-gal. Deane duplex pump was installed, driven by a Hercules turbine. Originally the potable water-supply was taken from the river above the power-canal inlet. The water now used comes from Auburn Lake, about 3 mi. north of the city, and is delivered to the pump well by gravity.

In 1914 the two old Worthington pumps were rebuilt by the Deane Steam Pump Co. These are now driven from a single shaft by two 380-hp. 33-in. Hercules turbines, one a right-hand and the other a left-hand. The teeth in the pinions of the old pumps were wood. In the rebuilt pumps they are cloth—"Fabroil," a patented product of the General Electric Co.—and at the time of their installation in the fall of 1914 were claimed to be the largest gears of this type in existence.

The pinions are 29.6 in. outside diameter, 1¼ in. diameter pitch and have 18¼ in. of cloth face between shrouds. They transmit 225 hp. at 80 r.p.m. The pressure on each tooth amounts to about 16,200 lb. The rebuilt pumps have a capacity of 4,000,000 gal. daily and have been in continuous operation for nearly two years. The plant is one of the quietest to be found where gear-driven pumps are in use.

The new driving gears are 113½ in. outside diameter, and each has 140 steel teeth. They weigh approximately 8 tons each. They are designed to be driven at 24 r.p.m., while the fastest the old pumps could be driven was 19 or 20 r.p.m. In actual operation the speed of the old pumps seldom exceeded 14 or 16 r.p.m., as the din and racket above this speed was unbearable. The Deane pump in the foreground of the accompanying view is still driven by a pinion with wood teeth. Its capacity is about a third

less than that of either rebuilt Worthington. The reconstruction of the pumps and the installation of "Fabroil" gears are estimated to have increased the capacity of the station 50% without altering the power equipment.

The water is pumped into the mains and to a 14,000,000-gal. distributing reservoir under a pressure of 100 lb. per sq.in. The normal consumption of the city is about 6,000,000 gal. daily. The minimum meter rate is 3½c. per 1,000 gal., which the superintendent of water-works, J. B. Longley, estimates is about the operating cost of the plant. There are few meters, and the use of water is generally unrestricted.

Typhoid Fever from Drinking Water Is Accident

The United States Circuit Court of Appeals, Ninth Circuit, recently handed down a decision (229 Federal Reporter, 552) which laid down the principle that the contracting of typhoid fever by employees as the result of drinking impure water furnished by the company is an accident arising out of the conduct of the business. The main parts of the decision, by Judge Ross, are as follows:

The defendant in error, the Pacific Gas and Coke Co., being engaged in the construction of a gas plant and having employed in the work a large number of men, secured from the Aetna Life Insurance Co., the plaintiff in error, a policy entitled by the latter "contractor's employers' liability policy," by which, in consideration of certain premiums which the case shows the defendant in error paid, it agreed to indemnify the assured (within certain amounts within which the present case falls) against loss and expense arising or resulting from claims upon the assured for damages on account of bodily injuries or death accidentally suffered, or alleged to have been suffered, by an employee or employees of the assured by reason of the business as described and conducted at the locations named in the policy, with certain exceptions not applicable here. In the course of the work certain of the employees of the Gas and Coke Co. contracted typhoid fever from the water furnished them by the latter, on account of which that company was compelled to pay damages to such injured employees, to recover the aggregate amount of which from the insurance company the present action was brought. And the sole point here presented is whether the harm so done to the workmen constituted a bodily injury accidentally received or suffered by them, within the meaning of the policy in question.

Of course it is not and cannot be doubted that the workmen were bodily injured by the drinking of the water in the course of the work, for it contained typhoid germs, which gave them typhoid fever; but it is insisted on the part of the plaintiff in error that in drinking the water they were but satisfying a natural want, and that in doing so there was no accident about it. It is readily conceded, of course, that there could be no accident in merely drinking water; but it is just as certain that the men would not have drunk it had they known that the water contained typhoid germs. The accident consists in that unexpected happening. Among the definitions of the word "accidental," in most, if not in all, of the dictionaries, is the happening of "something unexpectedly, unintentionally." Suppose, instead of containing typhoid germs, as in the present case, the water that the employees of the assured consumed had contained some of the most virulent poisons, would anyone contend that the injuries resulting therefrom could not be properly held to have been accidently inflicted? We think not, and yet, in our opinion, there is no substantial distinction between the case supposed and the case at bar.

The policy involved in the case of H. P. Hood & Sons vs. Maryland Casualty Co. (206 Mass., 223, 92 N. E. 329) was similar to that involved in the present case. There one Barry, who was employed by the plaintiff in that action as a hostler in its stables, had the care of horses which were afterward found to have been suffering from glanders, and Barry was directed to assist in cleaning up the stalls; no notice being given him that the horses had suffered from glanders. Subsequently he was attacked by that disease, and recovered judgment against the assured in that case for damages, which the assured paid, and sued the insurance company to recover the amount so paid, with costs and expenses of suit.

Inverted Sewer Siphons Under New York Subway*

By S. D. Bleich†

With the completion of the present New York subway contracts, 20 inverted sewer siphons will have been built. Of these, 11 are now in actual service, 4 are nearing completion and 5 will be completed within about one year.

These siphons are distributed in the different boroughs as follows: Manhattan, 3; Brooklyn, 13; Bronx, 4. Five have overflows crossing through the subway roof. The dimensions of these siphons are given in the accompanying table.

A typical inverted siphon on a combined sewer is shown by the drawing here reproduced. This crosses underneath a two-track subway station at Nostrand Ave. and Beverly Road. The complete separation of the dry-weather flow and the storm flow is affected at both chambers. The dry-weather flow is confined to the 14-in. pipe,

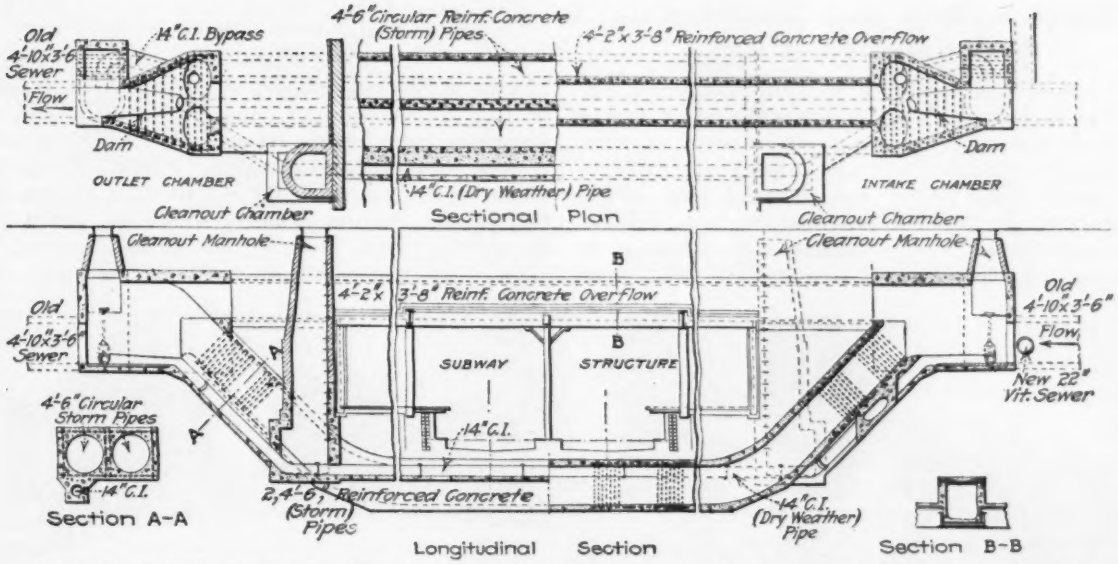
*Slightly condensed from "Public Service Record," April, 1916.

†Assistant Division Engineer, Public Service Commission for the First District, 120 Broadway, New York City.

DETAILS OF INVERTED SIPHONS, NEW YORK SUBWAY

Location	Size and Number of Pipes—Storm	Size and Number of Pipes—Sanitary	Size and Number of Pipes—Overflow	Capacity of Pipes, Cu.Ft. per Sec.—Storm	Capacity of Pipes, Cu.Ft. per Sec.—Sanitary	Capacity of Pipes, Cu.Ft. per Sec.—Overflow	Total Horizontal Length, Including Chambers, Ft.	Depression of Pipes Below Grade Line, Ft.	Difference of Invert Elevation of Chambers, Ft.	Estimated Cost	Date Completed
149th St. and Railroad Ave., Bronx...	2— 42-in.	1—14-in.	.....	120	6.0	...	66	9.3	0.1	$6,000	Feb. 1, 1902
Fourth Ave. and Dean St., Brooklyn.	2— 48-in.	1—18-in.	.....	266	11.0	...	135	13.7	0.9	11,100	July 8, 1911
Fourth Ave. and 7th St., Brooklyn...	2— 72-in.	1—30-in.	.....	330	25.0	...	82	3.4	3.0	4,700	Nov. 25, 1911
Fourth Ave. and 26th St., Brooklyn..	2— 54-in.	1—24-in.	.....	160	15.0	...	104	2.3	1.1	5,500	Jan. 27, 1912
Fourth Ave. and Butler St., Brooklyn	2—101-in.	1—16-in.	.....	680	12.0	...	100	19.5	0.1 & 0.9	11,900	Aug. 17, 1912
Fourth Ave. and 35th St., Brooklyn..	1— 24-in.	1— 6-in.	.....	19	1.2	...	117	12.1	1.5	3,800	Sept. 21, 1912
Lexington Ave. and 106th St., Manhattan	2— 48-in.	1—24-in.	.....	80	9.8	...	159	13.8	0.15±	19,000	Oct. 19, 1912
Lexington Ave. and 110th St., Manhattan	2— 78-in.	1—42-in.	.....	356	19.6	...	256	15.5	0.26±	52,000	Jan. 7, 1913
Fulton St. and Hudson Ave., Brooklyn	2— 24-in.	1—10-in.	ft.in. ft.in. 1 2x4 0	45	2.52	15±	141	22.0	0.6	8,500	Jan. 3, 1914
•20th Ave. between 63rd and 64th St..	1— 24-in.	1— 8-in.	.....	14	0.7	...	137	11.4	0.45	1,500	Aug. 20, 1914
•65th St. between 21st and 22nd Ave..	1— 16-in.	1— 8-in.	.....	68	0.8	...	162	10.4	0.66	2,100	Sept. 22, 1914
Southern Blvd. and 144th St., Bronx.	2— 30-in.	1— 8-in.	2 4x5 0	50	0.9	50±	115	15.4	1.0	4,000	.....
Southern Blvd. and Longwood Ave...	2— 30-in.	1— 8-in.	.....	61	0.65	...	134	11.7	3.5	5,000	.....
Southern Blvd. and 149th St., Bronx.	2— 48-in.	1—14-in.	.....	225	6.5	...	83	11.3	0.83±	11,000	.....
Seventh Ave. and 18th St., Manhattan	2— 60-in.	1—24-in.	.....	360	20.0	...	212	8.2	0.65	18,000	.....
Nostrand Ave. and Hortense St.....	2— 48-in.	1—12-in.	3 6x4 9	68	1.36	70±	102	14.48	0.07	8,200†	.....
Nostrand Ave. and Beverly Rd.....	2— 48-in.	1—14-in.	4 2x3 8	153	2.84	100±	152	15.85	0.50	6,400†	.....
Nostrand Ave. and Clarendon Rd.....	2— 36-in.	.....	2—24-in.	49	0.74	25±	86	14.25	0.13	4,200†	.....
Nostrand and Foster Ave.....	2— 48-in.	.....	.....	144	...	...	99	18.56	0.10	4,200	.....
Nostrand Ave. and Farragut Rd.....	2— 63-in.	1—20-in.	.....	263	6.82	...	124	12.75	0.10	9,400	.....

•Built under P. S. C. supervision. †Includes cost of overflow.



TYPICAL INVERTED SEWER SIPHON, NEW YORK SUBWAY, AT NOSTRAND AVE. AND BEVERLY ROAD

and when a storm occurs, the flow rises above the dam at the intake chamber and enters the two 4½-ft. storm pipes. The dam at the outlet chamber prevents the sanitary, or dry-weather, flow from getting into the storm pipes.

Two clean-out manholes are provided, one at each end of the horizontal stretch of 14-in. pipe. At the bottom of each of these manholes and on a line with the 14-in. pipe is a split pipe, the upper section of which can be removed, when necessary, for more effectually cleaning and rodding the small pipe.

A bypass is provided at each chamber for temporarily diverting the dry-weather flow from the small pipe into the outer storm pipe. This would be done at a time when it is found necessary to clean the small pipe thoroughly. Sand-bag dams would then be laid across the chambers between the walls of the permanent dams, and the sluice gates at the bypasses opened. The sanitary flow would then enter through the bypass into the outer 4½-ft. storm pipe and through the second bypass pipe at the outlet chambers into the sewer beyond, thus cutting off the flow from the 14-in. siphon pipe. This pipe could then be conveniently unwatered, the upper section of the split pipe at the cleanout manhole removed and thoroughly cleaned of all accumulations and obstructions.

The overflow crossing through the subway roof will act at times of very heavy storms and also at such times as the siphon pipes are obstructed.

Louis D. Fouquet is Division Engineer of Sewers, Public Service Commission, and the writer is in charge of the office work and design.

New York State Road Progress

State road construction in New York during 1915 is summarized in a report by the First Deputy, H. Eltinge Breed, to Commissioner Edwin Duffey, just made public. There were on Jan. 1, 1915, a total of 749 mi. of state road under contract and not completed. During the year 1,073 mi. additional were put under contract, and 760 mi. were completed and accepted while 324 mi. were completed too late for acceptance. Of the 1,073 mi. awarded, 381 mi. are of waterbound macadam; 176 mi. of waterbound macadam, surface treatment; 347 mi. of bituminous macadam, penetration method; 2.2 mi. of bituminous macadam, mixed method; 113 mi. of cement concrete pavement; 31 mi. of brick; 23 mi. of other types.

The average cost of construction of different classes of road was as follows:

	Cost per Sq. Yd. Pavement Only	Total Cost per Mile of Highway—16 to 26 Ft. Wide
Waterbound macadam	$0.648	$10,250
Bituminous macadam	.871	12,970
First-class concrete, 6 in. thick	1.121	15,320
Brick pavement on 5-in. concrete foundation	2.015	25,750

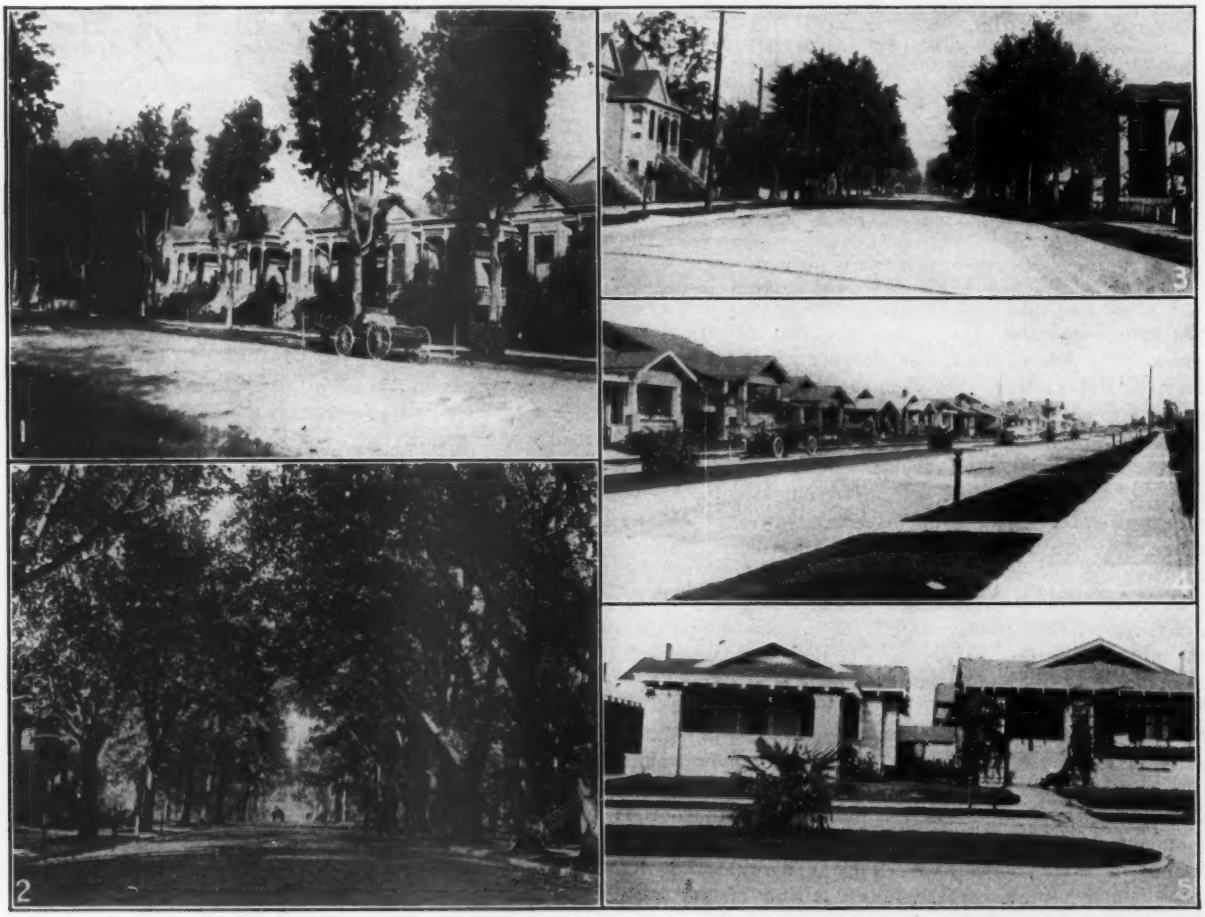
In all construction the state has been widening the pavement proper on curves and banking it in order that the fast moving motor traffic might be better safeguarded against accident. The slopes have been cut back and the clearing carried far enough along the inside of the curve to insure better sight distance for users of the road. Greater radius, wherever possible, has been given to the curve, in many cases to the extent of purchasing additional right of way.

During the past year the depth of pavements has been increased because of the large increase in the use of motor vehicles. There were 208,087 pleasure cars licensed in the state in the past year, and 23,585 commercial cars. The increased use of commercial trucks and the damage done by them to highways is alarming. Many of the old roads which were built only 6 in. in thickness have already begun to break up under this traffic, particularly at seasons of the year when ground water seeps through the soil under the pavement making it wet and unstable. At these times the vibratory action caused by the pounding from impact and by shifting of the heavy moving loads creates a shear in the pavement such as to break its bond. Raveling follows, and unless immediately taken care of the pavement rapidly disintegrates and failure is the result. As a factor against this, the state has been increasing the use of cut-off drain tile and designing roads of greater thickness, i. e., from 9 to 12 in. of stone according to the soil and traffic conditions to be encountered. It has also been the policy to build quite a number of miles of concrete roads, as these seem more adequately to meet this class of traffic.

Replanning and Districting Sacramento, Calif.

Now that it has awakened to the importance of considering its city plan, Sacramento, Calif., finds that it is greatly hampered by overwide streets where narrower ones would serve much better, that it lacks a satisfactory circulatory street system, due in large part to the adoption of the common gridiron plan, and that its industrial, business and residential sections need to be separated and kept distinct in accordance with some and goods and increase the income of the city from local taxes, because more property could be used productively.

Taking up first the general character and the width of some of Sacramento's streets, attention may be called to the five photographs presented herewith and the descriptive notes beneath them (Figs. 1 to 5). A study of these views and notes, together with an examination of the plan of the city (Fig. 6), shows in general that the tiresome gridiron layout of streets was followed in the old city. The views emphasize the fact that the excessive width of streets has tended to crowd the houses



FIGS. 1 TO 5. TYPICAL STREET SCENES IN OLD AND NEW RESIDENTIAL DISTRICTS OF SACRAMENTO, CALIF.

Fig. 1—Narrow lots, residences crowded, in old city. Fig. 2—A cool-looking old street; compare with treeless streets in annexed bungalow territory. Fig. 3—11th St. State Capitol in the distance (which is lost in this view) justifies a wide street, but the width is nevertheless accidental and is found in many Sacramento streets where not needed. Fig. 4—A row of crowded bungalows on an unnecessarily wide street in the annexed district. Fig. 5—Near view of bungalows on narrow lots in annexed district, with land to burn in the unnecessarily wide street

well-conceived plan. Sacramento has been helped to a clear vision of all this by a study and report made by John Nolen, landscape architect and city planner, of Cambridge, Mass.

As to the large part of the area of Sacramento given up to streets, Mr. Nolen said in a recent report:

> More than 50% of the area of the old city is taken up in streets and alleys, whereas 30% would be a liberal allowance for a city of the character of Sacramento. This means that at least 20% of the 3,000 acres of the old city, or about 600 acres of the most valuable land in Sacramento, is worse than wasted. These 600 acres would give the city many streets 100 ft. wide for transportation purposes, double the present number of plazas, provide three or four blocks for a liberal civic center and at least two blocks for each public school. Furthermore, it would reduce the cost of street upkeep many thousand dollars a year, save time in transit for both people

close together on lots with narrow frontage. This is strikingly evident in the newer sections of the city, where residences of the bungalow type almost touch each other (Figs. 4 and 5) and have their fronts close upon needlessly wide streets.

The general principle of zoning or districting cities, which has for some time been common abroad and is being urged more and more in this country, is too well known to need description. The city commissioners of Sacramento have adopted the three-zone plan, shown by Fig. 6. The industrial zone has railway connections or else they can be readily provided, and it is also near the waterfront. As there are now comparatively few industries in this section, it can readily be laid out with

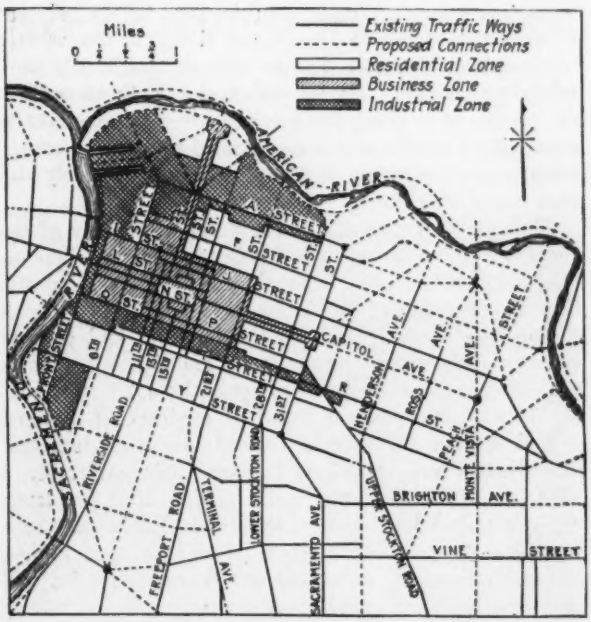


FIG. 6. MAIN THOROUGHFARE AND THREE-ZONE MAP ADOPTED BY CITY OF SACRAMENTO

streets of such a width and such a character of pavement and with such other improvements as may be required to meet the needs of an industrial zone.

The proposed business zone is already devoted to that purpose. Fig. 7 shows how frontage for business purposes may be provided in a neighborhood center and at the same time provision be made for open spaces and public and semipublic buildings. It is proposed to have such neighborhood centers as this at important street intersections, a fourth-mile or so apart, each complete in itself.

A portion of the residential district is located close by the industrial zone. The land thus set aside for residences is of low value. Studies designed to improve block and lot arrangements and to vary the width of streets according to sectional needs are shown by Fig. 8. Various restrictions for the three zones, including possible regulations of the height of buildings in the

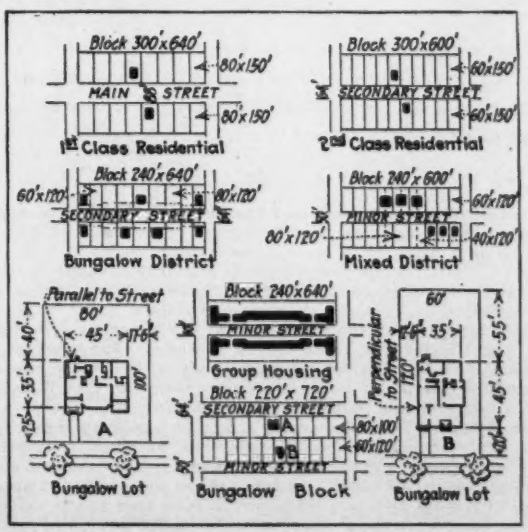


FIG. 8. PROPOSED BLOCKS AND LOTS IN ANNEXED DISTRICT OF SACRAMENTO

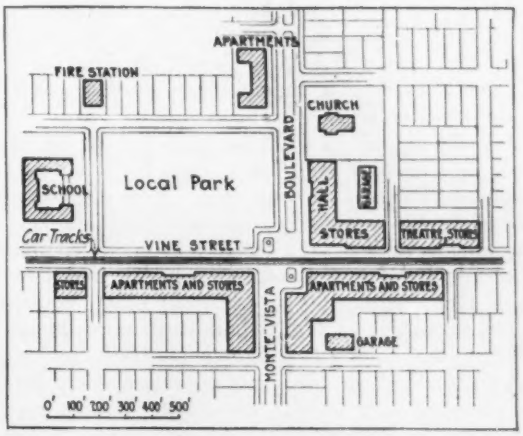


FIG. 7. LOCAL CENTER SCHEME, SACRAMENTO

business section and possible subdivisions of the residence zone into private-residence, tenement and apartment-house districts, are being given consideration by Mr. Nolen, in order to furnish a guide for future ordinances.

Engineers in Politics

By Thomas C. Desmond*

A good deal has been written and said recently in regard to the unfortunate fact that so few engineers ever occupy important administrative and executive positions in life as compared with men of other professions—lawyers, for instance, many of whom secure such positions. The point of this article is to suggest that engineers take more interest in politics and by so doing not only fulfill their plain duty and help the communities in which they live, but also supplement their technical experience with a broad understanding of men and affairs. There would be more engineers rightfully in prominent positions both in public and in private business life if more engineers had taken supplementary courses in the great graduate school of American politics.

By engineers in politics is meant engineers active in city, state or national political-party organizations—that is, engineers who take the time necessary to study the political issues of the day, who familiarize themselves with the machinery of popular government, who belong to local political clubs, who attend political meetings and party conventions and strive continually in a practical way to make their beliefs effective as regards good candidates for office and good party programs of legislation. Engineers active in politics in this way will benefit greatly the communities in which they live and will themselves be benefited. Let us consider this personal side first.

Activity in politics will benefit an engineer greatly because it will bring him into close and friendly relationships with other men of entirely different outlooks on life. It will give him a broader sympathy and understanding with men of other businesses and professions. It will strengthen his place in the community as a citizen and a man and not merely as a technical machine. By greatly enlarging his personal acquaintance it will give him the opportunity of learning to be a quick and accurate judge of men, which is a qualification necessary for the man who would hold many an important position.

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Activity in politics will help to teach the engineer how to express his ideas in terms that will be understood by other men. It will help to develop in him the power of forceful expression, the ability to persuade other men of the truth of what he says.

Activity in politics will also teach the engineer something he seldom, if ever, learns from his technical experience—to judge of shifting data. Most engineers have learned to reason correctly from data which are fixed and determinate, as is usually the case in purely engineering problems; but few engineers ever get so that they can fulfill that qualification which is so often required as vitally important in high administrative positions—the ability to find quickly the approximate truth from a complex problem not capable of exact solution where the data are changing even while a conclusion is being reached. Experience in studying political problems and in making decisions in political matters will help to develop this qualification in the engineer. Such experience would help to qualify for the presidency of a great corporation many a man who is now just a good chief engineer.

Few good engineers ever get beyond the chief engineer stage. They remain in a state of mind where they would be almost lost in dealing with the indefinite problems continually coming before an administrative executive, problems in which only a few moments' time can be given to consideration before a decision must be made; problems which no slide-rule or mathematical tables can solve and affairs is necessary for a correct solution. Engineers would occupy more executive positions of prominence, instead of letting the lawyers have most of them, if like the lawyers they sought more experience in politics of the kind which helps to give the training prerequisite to the proper filling of such positions.

In general, it will be a great benefit to the community in which the engineer lives to have him give part of his time to political work. It could easily be shown that most of the failures of our democracy—and we are far from having in America a very successful democracy—are due to the fact that a great many of our best qualified citizens do not attend properly to their political duties. On this ground alone it would be well to have engineers active in politics. But above this general reason there are several special reasons why the influence of engineers in politics would produce much good.

In the first place, the average engineer would bring with him into politics, regardless of everything else, a straight, clean character. In spite of the many faults and deficiencies of engineers as a class there is little question that association with engineering work does tend to bring out all there is of truth and honesty in a man. Just trying to design and build things strong and straight is what an engineer does all the time, and a little more of that spirit and influence in American politics would answer many of our governmental problems. There has been too much of the worst kind of the second-rate lawyer spirit of equivocation and specious pleading in American politics and too little of the straightforward, constructive, honest, unselfish work done by men to whom that kind of work is a matter of course.

While acknowledging the patriotism, the devotion and the vision of many of the lawyers who have borne the burden of public service and political work in the past when men of other professions and businesses, including engineers, were shirking this burden, one cannot help but think that it would be a very good thing for the country if the places of many lawyers now in public life were taken by engineers. The lawyer has essentially an analytical mind and is primarily a critic, while the engineer is essentially a builder and is accustomed to driving through constructive programs, of planning things definitely and then completing them.

The special familiarity of engineers with many of the functions of a government is another reason why their influence in politics would be for the good of the community. City governments in particular have largely to do with engineering matters, such as the building and care of streets and pavements, sewers, water and lighting systems, etc. State and national governments also are largely concerned with the administration of engineering matters.

Will engineers forever be content to remain technical subordinates and let others manage their government? This is a time of a great world crisis. New problems, many of them resulting from the war in Europe, are constantly coming up for solution by our political leaders and the electorate. After the war is over, America will have to solve many other governmental problems, mostly domestic. During this vital period of national adjustment, when democracy as never before will be on trial. shall engineers keep giving their best thought to their blueprints, with never any visions beyond such things as the strength of materials? Let it rather be said that engineers who live in this great democracy will fulfill their duty as American citizens by taking an active part in politics, by lending their strength in any way they can to assist in making our ideals of democracy successful, by helping to prove that it is not necessary to have a despotic militaristic state in order to have efficient city and national government.

And this is the great reason why engineers should be in politics, because America needs them. Activity in politics will benefit an engineer personally and make him more capable of holding an important administrative or executive position; but, much more than that, it will give him a great opportunity for doing good for others. In the old days of chivalry there was a phrase current—*noblesse oblige*. To the modern American engineer the interpretation of this might be: "If you have good judgment and clear vision enough to know how parties and governments should be run in a democracy and have some ideals of public service, it is your duty and your privilege to do your share in political work and strive to make your work effective for the good of all."

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Several Mining-Experiment Stations and three mine-safety stations have been located under the provisions of an act passed last year by Congress and appropriated for at the present session. The first of the experiment stations is to be at Fairbanks, Alaska, the second at Tucson, Ariz. The safety stations will be at Butte, Reno, and at Rapon, N. M. The sum of $25,000 is appropriated for each of the experiment stations and $101,500 for the three safety stations. The purpose of the stations is to make investigations with a view toward improving conditions in the mining, quarrying, metallurgical and other mineral industries, safeguarding life among employees, preventing unnecessary waste of resources and otherwise contributing to the advancement of these industries. Each of the safety stations is to be equipped with an all-steel mine-rescue car of special design. When not employed at the scene of a mine disaster, these cars will be sent to the various mining camps for the purpose of training the miners in rescue work.

Setting 10,000 Water Meters

In May, 1914, the City of Wilmington, Del., began installing water meters on all services. About half of the 20,000 services had been metered up to that time.

The first question confronting the Water Department was to decide between curb and cellar settings. After

FIG. 1. SHOP-WAGON FOR INSTALLING WATER METERS, WILMINGTON, DEL.

carefully considering the advantages of curb installations and the additional expense necessitated, the problem was solved by adopting the following policy: (1) Water meters to be set at curb on all new properties; (2) meters to be set at curb on properties without cellars, except where the probable life and nature of the building did not warrant the expense of a curb setting; (3) meters to be set at curb when requested by property owner; (4) meters to be set at curb where danger of freezing existed, if installed in cellar or where cellar did not permit convenient location from the meter reader's standpoint; (5) all meters not covered by the foregoing stipulations to be installed in cellars. The practical results of the above policy have been entirely satisfactory to the Water Department and to the property owners.

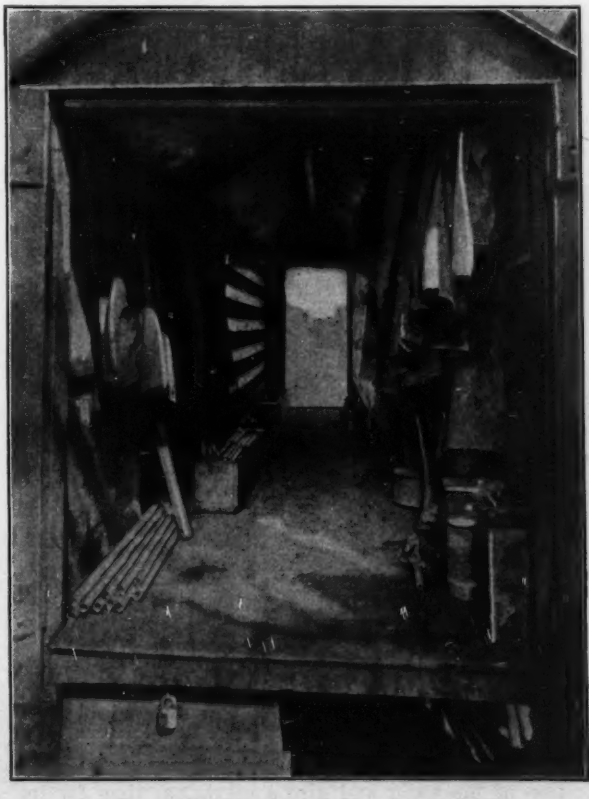

FIG. 2. INSIDE VIEW OF SHOP-WAGON

Organization and Equipment

The first step in establishing a working program was to subdivide the city into five installation districts and to work systematically in one district at a time. The force engaged varied from time to time in the number of laborers, but conformed on an average to the following schedule: 1 plumber; 7 pipe fitters; 8 helpers; 2 pavers; 2 drivers and from 10 to 20 laborers. The equipment included a cart and horse, motor truck and a wagon shop (see Figs. 1 and 2).

The meter installations were made under the direct supervision of S. N. Van Trump, Assistant Engineer and Superintendent of the Water Department. The plumber (37½c. per hr.) acted as foreman of the in-

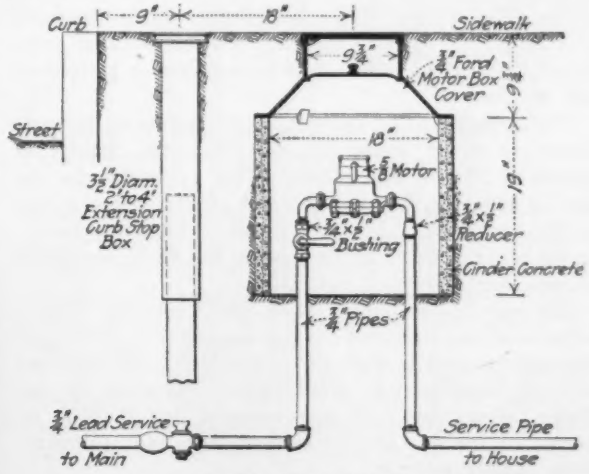

FIG. 3. STANDARD CURB METER SETTING, WILMINGTON, DEL.

stallation gang. All employees reported each morning at the wagon shop, which was located at the point of starting the day's work. The necessary equipment of tools and supplies was contained in this wagon. Depletions of stock were filled each day from the main storeroom by use of the motor truck.

Working Methods in Field

Slips were prepared each day at the main office, containing the street number of every house in the district in which the force was working, and a notation as to whether or not the house was already metered. These slips were distributed to the fitters at the start of the day's work and were turned in to the foreman as the meters were installed. They were then approved by him and returned to the main office for the purpose of permanent entry in the Water Department's books. In addition, each fitter was required to enter on a printed form a report of each meter installed, with its location, or notation of any service complications or other reason preventing its installation.

When such complications existed, the fitter's report was returned to the Engineering Department, and the property owner was notified by letter to remedy the condition within 30 days. At the expiration of this time an inspection was made; and if the situation had been corrected, the meter was ordered installed. For this purpose two men were employed who worked independently of the main force, in order that the progress of the latter might not be held up.

In cases where the property owner failed to comply with the requirements, the contract for a supply of water to such property was canceled. Service complications existing between the main and curb line were taken care of by the Water Department, while those existing between the curb and building line were corrected by the property owner. Before any meter was installed and prior to making an inspection for such purpose, the tenant of each house was supplied with literature explaining the nature of the work and the benefits to be derived.

Progress and Cost of Work

From May 8 to June 30, 1914, 1,233 meters were placed, of which 239 were curb and 994 cellar installations. From June 30, 1914, to July 1, 1915, the number of installations was 9,180, of which 4,055 were curb and 5,125 cellar settings. Throughout the winter the work was continued without interruption, the working force being confined to cellar installations during periods of bad weather.

The average cost of installing 5/8-in. meters at the curb, including meter, meter box, top, pipe and fittings as shown in Fig. 3, was $12.84. This price includes the cost of repaving, but not the cost of the curb-stop box or the curb stop. The average cost of installing meters in the cellar or other inside location was $8.55, including all necessary labor and material.

The standard meter box is of cinder concrete. These boxes were manufactured in large quantities by the Water Department, and to their use is due largely the low cost of curb installations. Experiments conducted by the Water Department have demonstrated that there is no danger of freezing in this climate from such comparatively shallow settings.

The work of installing meters disclosed an enormous amount of service complications and bad plumbing. The system of notices by letter, as well as frequent inspections, has resulted in correcting such conditions. The value of this work in reducing the water consumption, aside from the installation of meters, is difficult to estimate.

The foregoing data are taken from the recent annual report of the Board of Water Commissioners of Wilmington, of which Edgar M. Hoopes, Jr., is chief engineer.

Fish Screens for the head-gates of irrigation ditches are desired by the Federal Forest Service. The Government annually expends large amounts in stocking with trout the streams in the National Forest Reserves. The water from many of these streams is used for irrigation, and unless screens are placed at the head gates, many of the trout go down the irrigation ditches and are washed onto the fields to die. Most of the Western states have laws requiring that screens be placed at the head of irrigation intakes. Because of trouble from the clogging of the screens with floating drift, the irrigators oppose their use and the laws are not enforced. Unless a practicable screen can be devised which will eliminate the trouble from clogging, the Government is likely to restrict its work of stocking the headwaters of streams used for irrigation.

Brookline Iron-Removal Plant

F. F. Forbes, superintendent of water-works of Brookline, Mass., is chief engineer and general superintendent of construction of an interesting iron-removal filtration plant for that town, now nearing completion. Construction work is all being done by day labor, under Mr. Forbes' personal supervision, the original purpose being to furnish employment to the town's unemployed during the then prevailing hard times. Mr. Forbes is the practical designer of the plant, the detail plans of which, made by the town engineering department, commonly follow construction.

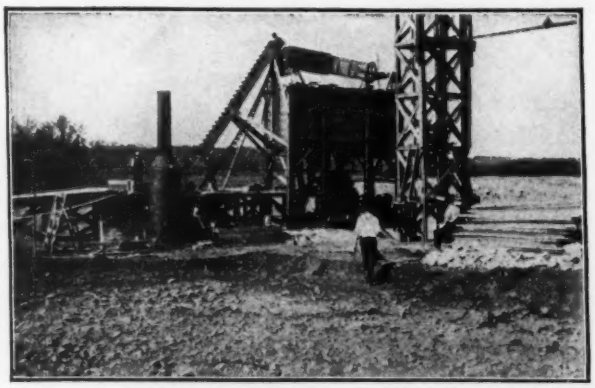

FIG. 1. CONSTRUCTION PLANT; BROOKLINE IRON-REMOVAL PLANT

The general layout of the plant is shown in the accompanying plan, Fig. 3. The water from the pumping station is distributed to the six 31-ft. concrete cylinders, which form the coke tricklers or prefilters. The depth of coke is to be 11½ ft. The water will be sprayed over the coke from perforated pipes laid over the surface of the beds.

From the coke prefilters the water, which has thus been thoroughly aërated, flows to the covered settling or coagulation basin, on the end of the first row of sand-filter beds. This basin is of similar construction and of the same size as one of the sand filters. It is divided into five compartments or channels by 8-in. brick walls, so that the water traverses the length of the basin five times before reaching the outlet. The object is to continue the aëration of the water and give a maximum time for its effect.

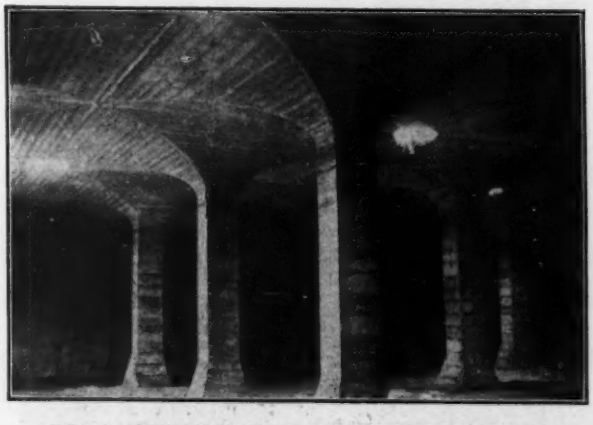

FIG. 2. INTERIOR VIEW OF COVERED FILTERS

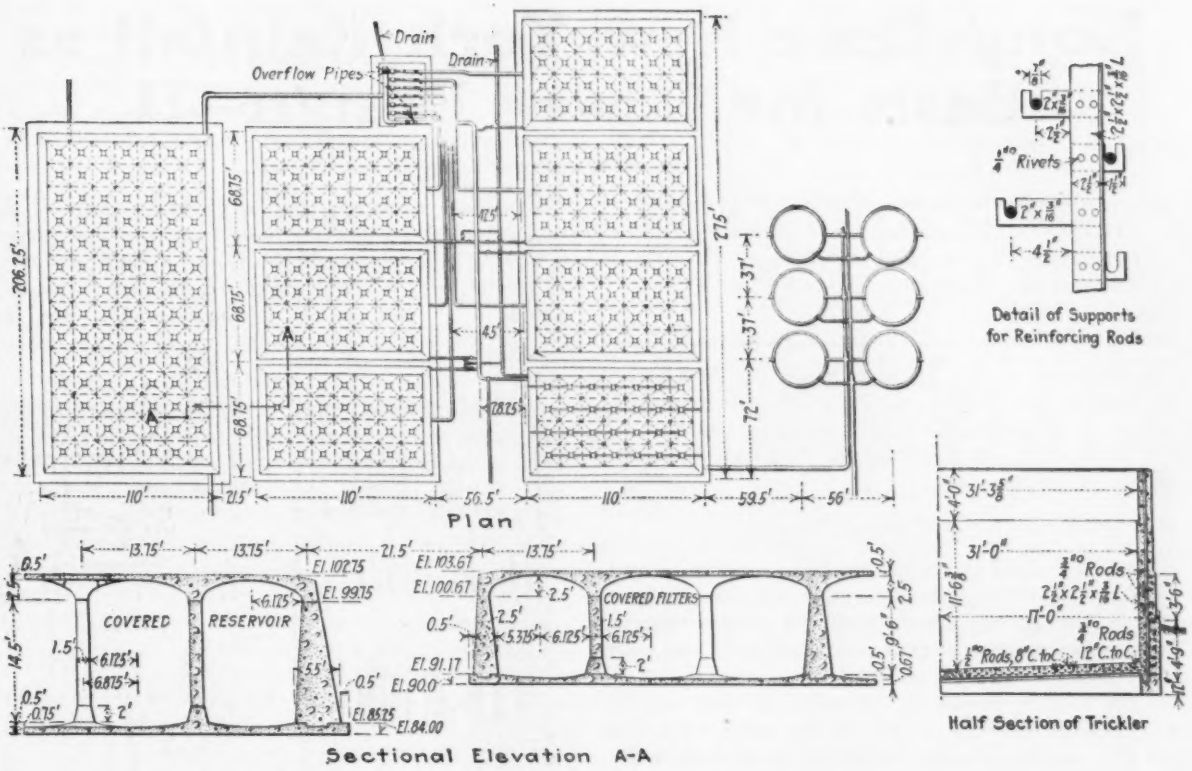

FIG. 3. GENERAL PLAN OF IRON-REMOVAL PLANT; F. F. FORBES, SUPERINTENDENT OF WATER-WORKS, BROOKLINE, MASS., ENGINEER AND SUPERINTENDENT OF CONSTRUCTION

From the coagulation basin the water may be drawn off through the gate house to the clear-water reservoir at the left of the filters, Fig. 3, or it may be passed into any one or all of the six filters, which have a combined area of one acre, and are designed for a daily capacity of 10,000,000 gal. The filter floor adjacent to the drains is depressed and the drains are built in the form of concrete boxes entirely above the floor, the object being to make all parts of the drains easily accessible.

The clear-water reservoir holds a day's supply. The water flows from it by gravity back to the pumping station, where it is repumped into the mains. The gate house is built alongside the second row of filters. The effluent pipe from each filter bed is equipped with a venturi meter. Two open-end overflow pipes are provided, one on the filter line and one on the reservoir line. These are so placed that they will waste the entire flow, if necessary, and make it impossible to get pressure on the filter or reservoir roofs, which has been the cause of failure in one or more filtration plants.

The construction plant was simply and economically arranged. A gravel bank is adjacent to the plant. The concrete mixer was set up under the screened gravel bins (see Fig. 1) and the aggregates chuted into the mixer hopper. The concrete was distributed to the various parts of the work from a tower by means of chutes. The same screening plant and bins are used for separating the sand for the filter beds, although sand from another bank, some distance away, was used.

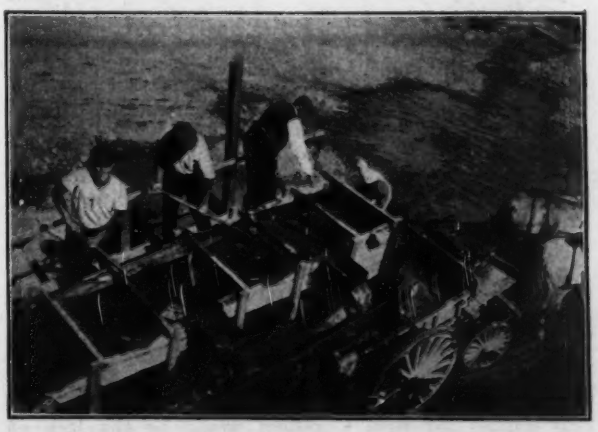

FIG. 4. SAND-WASHING DEVICE FOR FILTER SAND

The sand-washing device for the filter sand is shown in Fig. 2. This consists of a trough built out from the sand spout of the bins. There is sufficient water in this sand as it comes from the screen to make it flow into this trough. Along the bottom of the trough is a perforated pipe, which also admits water under considerable pressure. Two overflow spouts are provided on the sides of the trough, which carry off the dirty water. A baffle is built just beyond the second waste spout, under which the clean sand is carried into the end compartment, where it is drawn off through an ordinary pipe gate-valve. Water is admitted to the compartment containing the clean sand from the pipe on the bottom, in order to keep the sand in suspension and make it flow readily through the outlet valve. By varying the size of the holes in the bottom water-inlet pipe just the right size sand could be saved and the mud and small-sized material washed away. The sand used is rather coarse.

Long-Time New York Rainfall as Basis for Sewer Design--II

By O. Hufeland*

SYNOPSIS—Tabulations and diagrams of the New York City rainfall for the years 1869 to 1913 inclusive, being a continuation of those in the issue of Aug. 31.

In the issue of Aug. 31, 1916, p. 393, the first part of this article was devoted mainly to the "Average-Rate" method of tabulating the 45-yr. of rainfall available in New York City. In this issue the "Uniform-Intensity" method will be taken up.

Uniform Intensities of Precipitation

In the "uniform-intensity" method the rates of precipitation above the minimum previously described are compiled for periods during which they were uniform. This method consists in giving the intensities and their duration as they actually occurred. For instance, a 2-in. rate for 15 min. means that it rained at that rate for every minute of the 15, while in the other method it generally means that the average of several rates for that period was 2 in. per hr.

Table 4 gives the date, duration, quantity of rainfall and rate of uniform intensities for the years from 1869 to 1913. Table 5 gives the same figures arranged by time from 2 to 70 min., the latter being the longest period during which a uniform intensity of a sufficient rate occurred. Fig. 3 shows the frequency and rate arranged in the order of their occurrence, beginning at 5 min. These tables and this diagram correspond to Tables 1 and 2 and Fig. 1 of the first method. Fig. 4 substantially corresponds to Fig. 2, showing the frequency curves, except that it shows all the recorded intensities for the whole 45 yr.[1]

The two methods give widely different records for the same storm, and it will be interesting to compare them.

Preliminary to such a comparison it will be necessary to get a clear understanding of the word "average" as it is used here. Average is the mean of a number of points of a known value without a limitation as to the distance these points are apart. When all the data and the time to analyze them are available an average should not be misleading; when this is not the case it may be very misleading. An illustration may simplify my meaning. If 24 cars pass a given point in 24 hr. the average is one car per hour, even if all the 24 pass in 5 min. The average is correct, but misleading; again, if the cars passed at regular intervals of an hour and carried a total of 600 passengers daily, the average would be 25 per hr., even if six of the cars carried all the passengers in 6 hr. and not one in the other 18. Such an average, like the preceding one, would be misleading.

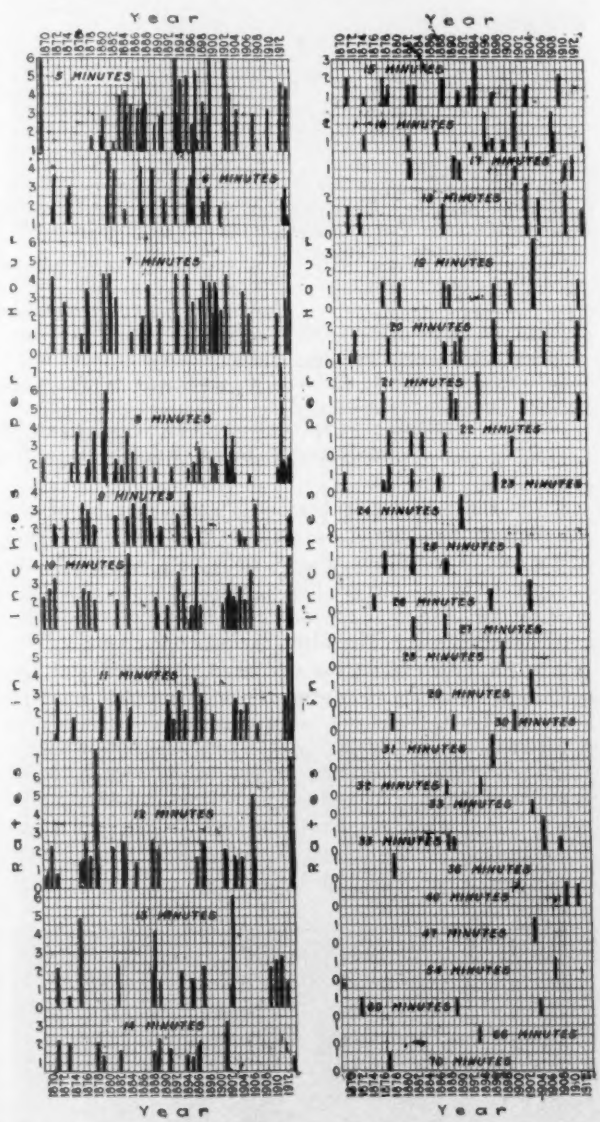

FIG. 3. RATES AND FREQUENCY OF "UNIFORM INTENSITIES" OF RAINFALL AT NEW YORK CITY, 1869-1913

Now if it was necessary to transfer these passengers it is clear that any transfer system that could carry only 25 passengers an hour would be hopelessly flooded on the arrival of the first car with passengers or idle if the empty cars arrived first. The application is obvious. The only excuse for such a system would be the lack of knowledge as to the time and rate of arrival at the

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[1]In Fig. 4 I have drawn a dotted line that may be considered a maximum curve with an equation $I = \frac{72}{t+1}$. I have experimented with other curves on this diagram, and if it is thought desirable to lay down curves for use I would suggest that the numeral in the divisor be increased by 1 ($t + 1$, $t + 2$, $t + 3$) until the desired curve is obtained; if this is done to $t + 10$ the curve obtained will just come within the dated points. Such curves have naturally no relation to any period of frequency like that claimed for those of the other method, but will show what points are enveloped and which are omitted, while the dates will show when they occurred. Such a curve is a simple guide with all the data upon which it is based before the engineer.

transfer point. A similar lack may have been the reason for the common use of the "average rate" of rainfall in sewer design. But the possession of such knowledge requires an analysis that may throw a new light on the use of rainfall records.

The value of any theory for determining the quantity of water to be carried off by storm sewers must depend upon the correct use of the data. Let us see if the "average rate" method provides such a use.

In the year 1913 three heavy storms occurred. The exceedingly large quantity of rain that fell in a short period would favor the application of the "average rate" method to these storms rather than to longer ones with less rain and will therefore furnish a fair illustration. These storms were accurately recorded on July 28, Sept. 4 and Oct. 1 of that year at the Central Park observatory by a Frieze self-recording rain gage, under the supervision of the United States Weather Bureau, and are carefully plotted in a cumulative form in Fig. 5. Lines drawn through the plotted points show each of the assumed "uniform intensities" of rainfall. Directly above these are plotted diagrams showing these rates in the order of their occurrence, their relation to each other and their duration. On the same diagram are tabulations of the "average rates" for the three storms. The July 28 storm lasted 85½ min., during which 2.98 in. of rain fell giving an "average rate" of 2.09 in. per hr. Such a rate occurred at no time during the storm, the nearest being three widely separated periods, together 18½ min., during which the rate was about 2.50 in. Of the other "average rates" not one, even approximately, corresponds to an actual occurrence. Out of the total of 85½ min., for 30 min. the rate was less than 0.7 in.; for 22 min. it was less than 1.5 in.; for 18½ min. it was about 2.5 in.; for 4½ min., 4.4 in.; and for 10½ min. it was 6.3 in. An "average" for 85½ min. of such rates is grossly misleading. The storm of Sept. 4 lasted 80 min., during which 3.62 in. of rain fell; and for this an "average rate" of 2.70 in. per hr. is given. The nearest approach to such a figure is a rate of 3.84 in., which lasted 2½ min., the next being two periods of 10 and 12 min., for which the rate was 1.80 in. Between these there was an interval of 3 min. when it did not rain at all. For 24 min. of the total 80 it rained at the rate of 0.75 in. per hr.; for 5½ min., 1.52 in.; for 22 min., 1.80 in.; for 2½ min., 3.84 in.; for 11 min., 5.18 in.; for 12 min., the rate was 7 in., and for 3 min. no rain fell. In the first 31 min., 2.65 in. of rain fell, which would give an "average rate" of 5.16 in. In the last 49 min. 0.97 in. fell, giving an average rate of 1.20 in. An average of 2.70 in. per hr. for the whole 80 min. approaches the limits of absurdity. Would a sewer designed to carry off 2.70 in. of rainfall in an hour carry off 2.65 in. in 31 min.?

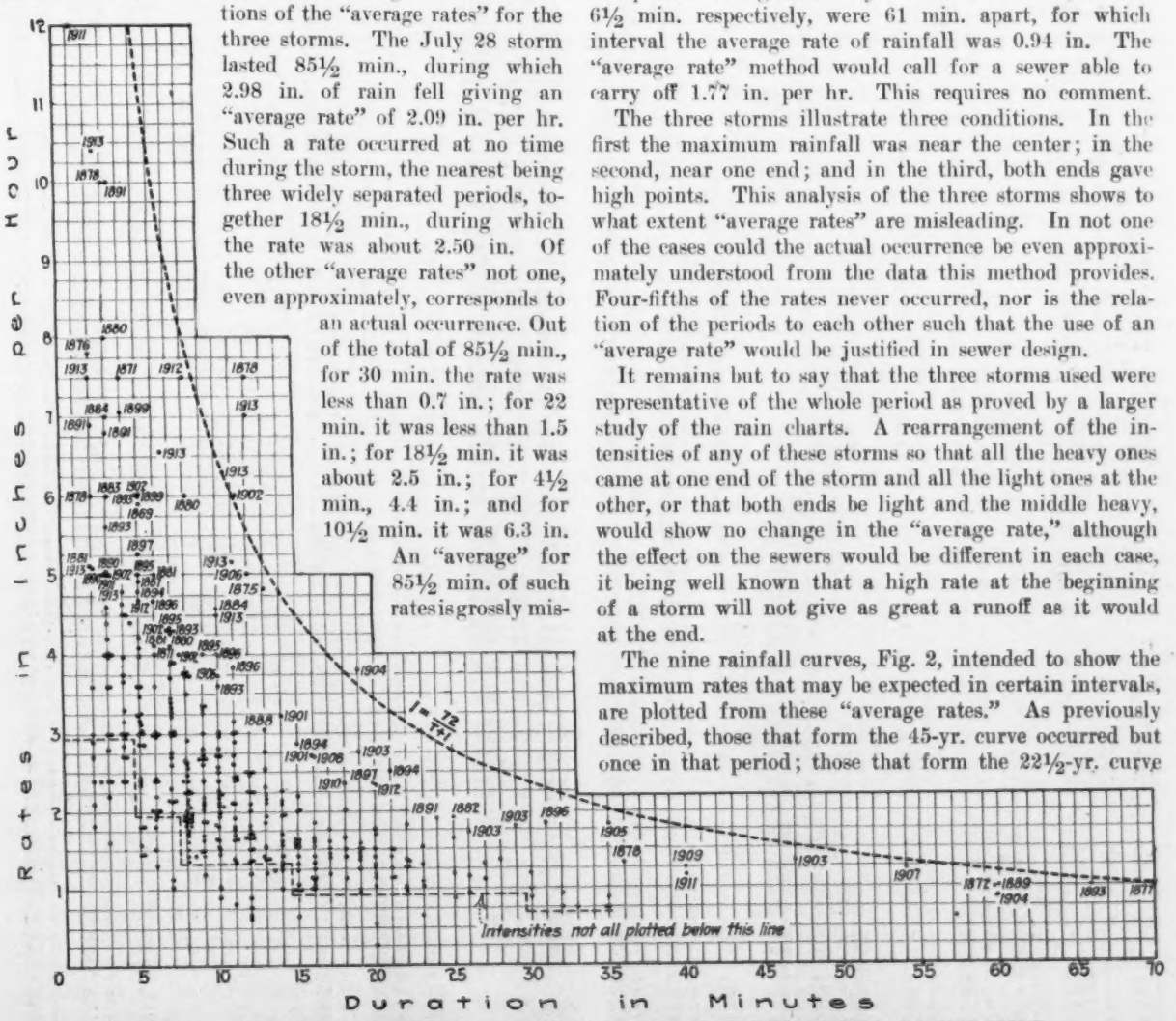


FIG. 4. "UNIFORM INTENSITIES" OF RAINFALL, NEW YORK CITY, 1869 TO 1913, INCLUSIVE
A total of 235 storms and 455 points were plotted

The third storm occurred on Oct. 1 and lasted 109 min., for which the "average rate" is 1.77 in. per hr. Of this total of 109 min., for 8 min. it did not rain at all; for 51½ min., at less than 1.05 in. per hr.; 6 min., 1.30; 10 min., 1.50; 8 min., 1.95; 9 min., 2.80; 10 min., 4.50; and 6½ min, 6.66 in. per hr. The two last periods of high intensity but short duration, 10 and 6½ min. respectively, were 61 min. apart, for which interval the average rate of rainfall was 0.94 in. The "average rate" method would call for a sewer able to carry off 1.77 in. per hr. This requires no comment.

The three storms illustrate three conditions. In the first the maximum rainfall was near the center; in the second, near one end; and in the third, both ends gave high points. This analysis of the three storms shows to what extent "average rates" are misleading. In not one of the cases could the actual occurrence be even approximately understood from the data this method provides. Four-fifths of the rates never occurred, nor is the relation of the periods to each other such that the use of an "average rate" would be justified in sewer design.

It remains but to say that the three storms used were representative of the whole period as proved by a larger study of the rain charts. A rearrangement of the intensities of any of these storms so that all the heavy ones came at one end of the storm and all the light ones at the other, or that both ends be light and the middle heavy, would show no change in the "average rate," although the effect on the sewers would be different in each case, it being well known that a high rate at the beginning of a storm will not give as great a runoff as it would at the end.

The nine rainfall curves, Fig. 2, intended to show the maximum rates that may be expected in certain intervals, are plotted from these "average rates." As previously described, those that form the 45-yr. curve occurred but once in that period; those that form the 22½-yr. curve

TABLE 4. STUDY OF RAINFALL AT NEW YORK CITY, 1869 TO 1913, BY "UNIFORM-INTENSITY" METHOD

Dates, Duration in Minutes, Together with Totals for Each Rainfall and Rates per Hour in Inches

Date	Year	Min.	Rainfall	Rate
June 21	1869	12	0.13	0.65
		12	0.18	0.90
		8	0.32	2.40
		20	0.18	0.54
		20	0.09	0.27
Aug. 13	1869	5	0.49	5.88
		10	0.07	0.42
Aug. 15	1869	10	0.37	2.22
June 27	1870	12	0.45	2.25
		23	0.41	1.08
July 28	1870	10	0.45	2.70
June 7	1871	7	0.48	4.11
		9	0.34	2.22
		29	0.13	0.27
		8	0.05	0.38
July 16	1871	18	0.45	1.50
		10	0.50	3.00
		12	0.15	0.75
		20	0.15	0.45
Aug. 4	1871	9	0.25	1.62
Aug. 16	1871	15	0.50	2.00
Sept. 26	1871	14	0.49	2.10
		3	0.15	3.00
		11	0.15	0.80
		12	0.10	0.60
		27	0.11	0.25
Oct.	1871	13	0.46	2.12
		4	0.50	7.50
		2	0.09	2.70
Oct. 26	1871	3	0.18	3.60
		11	0.50	2.73
		6	0.19	1.90
July 4	1872	20	0.57	1.71
July 25	1872	60	1.00	1.00
July 5	1873	14	0.45	1.92
		3	0.20	4.00
July 27	1873	18	0.34	1.13
		7	0.32	2.72
Aug. 21	1873	13	0.12	0.55
		9	0.40	2.40
July 10	1874	8	0.27	2.02
		6	0.24	2.40
		5	0.15	1.80
		6	0.30	3.00
		16	0.38	1.40
July 12	1874	15	0.24	0.96
		2	0.26	7.80
		11	0.31	1.70
June 22	1875	10	0.35	2.10
July 26	1875	13	1.05	4.81
		4	0.18	2.70
Aug. 18	1875	26	0.41	0.95
		8	0.50	3.75
		12	0.27	1.35
May 22	1876	10	0.45	2.70
July 11	1876	12	0.30	1.50
Aug. 16	1876	7	0.12	1.02
		12	0.50	2.50
		9	0.50	3.33
June 21	1877	70	1.18	1.02
July 3	1877	7	0.40	3.40
July 9	1877	19	0.45	1.42
July 17	1877	8	0.24	1.80
		3	0.08	1.60
		9	0.45	3.00
		7	0.38	3.27
		3	0.11	2.20
Aug. 14	1877	8	0.30	2.25
Aug. 14	1877	12	0.34	1.70
Aug. 25	1877	10	0.43	2.58
Oct. 4	1877	15	0.16	0.64
		25	0.50	1.20
		15	0.50	2.00
		21	0.53	1.50
		23	0.25	0.65
June 21	1878	15	0.27	1.08
		23	0.58	1.51
July 10	1878	9	0.33	2.16
July 21	1878	10	0.35	2.10
July 31	1878	20	0.48	1.44
		22	0.50	1.37
Aug. 1	1878	14	0.47	2.01
		15	0.39	1.56
Aug. 5	1878	8	0.50	3.75
		12	1.50	7.50
		3	0.50	10.00
Sept. 4	1878	12	0.24	1.20
		2	0.20	6.00
		36	0.80	1.33
		3	0.15	3.00
Nov. 27	1878	30	0.50	1.00
June 15	1879	14	0.50	1.28
Aug. 25	1879	11	0.45	2.45
July 12	1880	3	0.40	8.00
		2	0.10	3.00
		3	0.12	2.40
		3	0.35	7.00
		8	0.50	3.75
July 27	1879	7	0.50	4.29
Aug. 10	1879	5	0.24	2.88
Aug. 2	1879	8	0.40	6.00
Aug. 25	1879	5	0.15	1.80
		19	0.45	1.41
May 22	1881	6	0.50	5.00
		7	0.50	4.29
		2	0.17	5.10
July 4	1881	12	0.45	2.25
Aug. 7	1881	7	0.38	3.26
June 15	1882	4	0.26	3.90
June 19	1882	17	0.45	1.60
June 26	1882	9	0.40	2.67
Sept. 11	1882	15	0.40	1.60
		10	0.35	2.10
Sept. 20	1882	2	0.13	3.90
Sept. 22	1882	7	0.35	3.00
		13	0.50	2.31
		14	0.36	1.56
Sept. 23	1882	3	0.14	2.80
		22	0.50	1.37
		8	0.20	1.50
		9	0.17	1.18
		4	0.20	3.00
		2	0.12	3.60
		2	0.08	2.40
		16	0.35	1.32
		27	0.50	1.11
		4	0.18	2.70
		5	0.12	1.44
		8	0.30	2.25
		11	0.55	3.00
		25	0.80	1.92
		23	0.50	1.30
May 21	1883	15	0.40	1.60
		12	0.50	2.50
		3	0.20	6.00
		12	0.33	1.65
June 6	1883	4	0.31	4.65
July 13	1883	2	0.06	1.80
		5	0.43	3.96
		8	0.25	1.88
June 25	1884	6	0.18	1.80
		4	0.16	2.40
		11	0.31	1.70
July 12	1884	11	0.40	2.20
Aug. 5	1884	5	0.35	4.20
		4	0.16	2.40
Aug. 22	1884	10	0.46	4.60
		8	0.50	3.75
		9	0.39	2.60
Aug. 30	1884	3	0.22	4.40
		5	0.25	3.00
		22	0.47	1.28
June 5	1885	8	0.35	2.63
July 29	1885	5	0.29	3.48
Aug. 3	1885	7	0.13	1.12
		9	0.50	3.33
		12	0.27	1.35
Nov. 18	1886	5	0.28	3.26
May 31	1887	5	0.12	1.44
		7	0.30	2.60
		9	0.50	3.33
		2	0.07	2.10
June 17	1887	5	0.28	3.36
June 20	1887	6	0.41	4.10
June 22	1887	8	0.25	1.88
		3	0.20	4.00
		6	0.20	2.00
Aug. 18	1887	5	0.41	4.92
Aug. 21	1887	5	0.30	3.60
Aug. 22	1887	16	0.41	1.60
		23	0.38	1.00
Aug. 24	1887	7	0.35	3.00
May 28	1888	27	0.59	1.31
May 29	1888	14	0.37	1.60
June 26	1888	13	0.40	1.85
		7	0.38	3.70
July 19	1888	9	0.40	2.67
July 31	1888	25	0.36	0.86
Aug. 4	1888	20	0.38	1.14
		9	0.28	1.86
		12	0.50	2.50
Aug. 4	1888	15	0.50	2.00
Aug. 21	1888	35	0.50	0.86
		15	0.50	2.00
		32	0.40	0.75
		20	0.35	1.05
		18	0.50	1.67
Sept. 8	1888	19	0.47	1.50
Sept. 12	1888	7	0.27	1.60
Sept. 17	1888	22	0.47	1.28
Sept. 20	1888	13	0.66	3.05
April 12	1889	3	0.20	4.00
June 11	1889	12	0.40	2.00
June 15	1889	8	0.29	1.78
July 4	1889	30	0.45	0.90
July 19	1889	14	0.31	1.33
July 27	1889	35	0.45	0.75
		21	0.53	1.50
July 30	1889	4	0.25	3.75
		13	0.30	1.38
		60	1.00	1.00
July 31	1889	6	0.30	3.00
Aug. 2	1889	6	0.30	3.00
Aug. 13	1889	19	0.40	1.26
Sept. 13	1889	5	0.20	2.40
Sept. 17	1889	14	0.53	2.27
May 4	1890	3	0.25	5.00
June 6	1890	7	0.35	1.80
		3	0.25	5.00
June 11	1890	4	0.21	3.15
June 13	1890	4	0.19	2.85
		21	0.38	1.13
July 17	1890	10	0.38	2.28
Aug. 22	1890	17	0.50	1.77
Aug. 29	1890	9	0.25	1.68
Sept. 16	1890	5	0.24	2.88
		9	0.31	2.07
Sept. 17	1890	20	0.40	1.20
Oct. 10	1890	10	0.24	1.44
April 18	1891	11	0.30	1.64
April 23	1891	5	0.26	3.12
June 17	1891	14	0.40	1.72
July 23	1891	11	0.48	2.62
Aug. 23	1891	4	0.20	3.00
		24	0.76	1.90
		15	0.33	1.32
Sept. 5	1891	11	0.36	1.98
June 9	1892	4	0.24	3.66
		11	0.30	1.64
		8	0.24	1.80
July 3	1892	3	0.50	10.00
		4	0.22	3.30
Aug. 5	1892	17	0.41	1.51
Aug. 9	1892	6	0.24	2.40
		20	0.50	1.50
Sept. 13	1892	2	0.23	6.90
		10	0.30	1.80
May 3	1893	15	0.39	1.56
June 6	1893	11	0.58	3.16
		9	0.41	2.73
July 26	1893	3	0.28	5.60
Aug. 19	1893	10	0.60	3.60
Aug. 20	1893	6	0.40	4.00
		5	0.50	6.00
		7	0.50	4.30
		7	0.23	1.96
Aug. 23	1893	66	1.09	1.00
Sept. 7	1893	13	0.42	1.94
Oct. 27	1893	5	0.25	3.00
		16	0.27	1.00
July 29	1894	10	0.40	2.40
Aug. 3	1894	5	0.40	4.80
Aug. 15	1894	14	0.33	1.40
Sept. 8	1894	15	0.72	2.88
		21	0.87	2.50
Sept. 16	1894	11	0.32	2.10
May 27	1895	4	0.20	3.00
June 5	1895	9	0.60	4.00
July 27	1895	8	0.23	1.73
July 30	1895	14	0.30	1.29
Aug. 4	1895	9	0.22	1.47
		13	0.33	1.52
		10	0.17	1.02
Aug. 6	1895	5	0.50	5.00
		10	0.27	1.62
Aug. 31	1895	7	0.50	4.30
		13	0.30	1.38
Feb. 6	1896	26	0.50	1.15
May 28	1896	14	0.45	1.93
June 10	1896	3	0.34	6.80
June 21	1896	10	0.27	1.62
		31	0.95	1.84
		16	0.70	2.62
July 15	1896	6	0.36	3.60
		6	0.30	3.00
		8	0.26	2.10
July 12	1896	5	0.20	2.40
		6	0.20	2.00
		14	0.50	2.14
July 20	1896	16	0.27	1.01
		7	0.32	2.75
July 27	1896	12	0.33	1.65
July 30	1896	10	0.40	4.00
Sept. 3	1896	11	0.70	3.82
Sept. 15	1896	4	0.30	4.50
Sept. 18	1896	6	0.47	4.70
May 24	1896	5	0.46	5.28
		12	0.50	2.50
June 9	1897	9	0.32	2.10
		19	0.43	1.36
July 12	1897	10	0.30	1.80
July 21	1897	8	0.39	2.93
July 23	1897	20	0.78	2.34
July 28	1897	23	0.42	1.10
		20	0.42	1.26
Aug. 4	1897	15	0.31	1.24
Aug. 23	1897	13	0.47	2.17
		12	0.45	2.25
		11	0.55	3.00
		5	0.13	1.56
Sept. 1	1897	7	0.35	3.00
		16	0.33	1.24
Apr. 24	1898	5	0.30	3.60
July 4	1898	7	0.46	3.93
Aug. 24	1898	6	0.22	2.20
June 15	1899	28	0.80	1.36
June 28	1899	6	0.30	3.00
July 12	1899	16	0.30	1.12
		5	0.25	3.00
Aug. 10	1899	4	0.47	7.05
Sept. 1	1899	5	0.50	6.00
		11	0.35	1.91
Sept. 3	1899	7	0.45	3.86
		8	0.32	2.40
May 19	1900	8	0.27	2.02
		19	0.50	1.58
June 8	1900	30	0.60	1.20
June 27	1900	22	0.38	1.04
Aug. 12	1900	4	0.20	3.00
Aug. 15	1900	7	0.25	2.14
Aug. 17	1900	20	0.43	1.29
Aug. 26	1900	7	0.45	3.86
		7	0.40	3.43
July 5	1901	3	0.25	5.00
		12	0.42	2.10
		7	0.27	2.31
		3	0.18	3.60
		15	0.40	1.60
		3	0.21	4.20
		16	0.72	2.70
July 6	1901	14	0.75	3.21
July 17	1901	10	0.32	1.92
Aug. 24	1901	17	0.34	1.20
		25	0.68	1.63
		6	0.20	2.00
		12	0.36	1.80
June 21	1902	4	0.30	4.50
		13	0.26	1.20
July 20	1902	10	0.35	2.10
July 28	1902	13	1.31	6.06
		3	0.25	5.00
Aug. 5	1902	8	0.30	2.25
		5	0.50	6.00
		7	0.50	4.28
Aug. 19	1902	10	0.50	2.50
		8	0.25	1.88
Feb. 28	1903	5	0.34	4.08
June 14	1903	26	0.74	1.70
June 21	1903	10	0.38	2.28
June 29	1903	33	0.40	0.73
		8	0.35	2.62
		18	0.83	2.77
July 2	1903	11	0.44	2.40
July 22	1903	8	0.47	3.52
July 30	1903	15	0.36	1.44
		12	0.35	1.75
		15	0.40	1.60
Sept. 17	1903	10	0.33	1.98
Oct. 8	1903	3	0.23	4.60
		16	0.30	1.12
		11	0.50	2.73
		12	0.30	1.50
		8	0.25	1.88
		29	0.85	1.78
Oct. 9	1903	47	1.07	1.36
May 30	1904	11	0.40	2.10
		60	0.87	0.87
July 28	1904	5	0.27	3.24
Aug. 19	1904	19	0.30	0.95
		19	1.20	3.80
		9	0.28	1.87
Sept. 14	1904	10	0.47	2.82
		12	0.33	1.65
June 22	1905	11	0.45	2.45
		35	1.07	1.83
July 29	1905	10	0.35	2.10
Aug. 13	1905	7	0.39	3.34
		9	0.22	1.47
Oct. 19	1905	18	0.60	2.00
May 5	1906	12	1.00	5.00
May 27	1906	8	0.19	1.42
		12	0.34	1.70
		7	0.25	2.14
July 10	1906	20	0.58	1.74
July 17	1906	10	0.62	3.72
Aug. 9	1907	5	0.25	3.00
Aug. 24	1907	54	1.10	1.22
Sept. 11	1907	9	0.49	3.27
		11	0.25	1.36
July 24	1908	16	0.72	2.70
		16	0.41	1.54
Sept. 28	1908	3	0.20	4.00
		35	0.45	0.77
June 28	1909	15	0.55	2.20
		40	0.84	1.26
Aug. 13	1907	13	0.48	2.21
Mar. 27	1910	5	0.27	3.24
June 10	1910	13	0.55	2.54
		17	0.40	1.41
June 11	1910	18	0.71	2.36
		32	0.50	0.94
July 30	1911	13	0.60	2.78
Aug. 15	1911	1	0.20	12.00
		7	0.25	2.14
		10	0.30	1.80
Aug. 24	1911	8	0.25	1.88
		40	0.78	1.17
Oct. 19	1911	17	0.52	1.84
Feb. 27	1912	11	0.53	2.90
May 30	1912	8	1.00	7.50
June 17	1912	5	0.39	4.68
July 21	1912	20	0.78	2.34
		38	0.30	2.25
		8	0.25	1.88
Oct. 23	1912	19	0.50	1.58
		21	0.50	1.43
		6	0.24	2.40
		13	0.30	1.38
Oct. 24	1912	21	0.44	1.26
Mar. 26	1913	7	0.35	3.00
June 30	1913	2	0.25	7.50
		3	0.12	2.40
		6	0.30	3.00
July 1	1913	18	0.42	1.40
		2	0.17	5.10
July 24	1913	6	0.15	1.50
		2	0.35	10.50
		8	0.18	1.35
		4	0.32	4.80
July 28	1913	10½	1.10	6.30
		2½	0.10	2.40
		8	0.33	2.46
		8½	0.20	1.41
		4½	0.33	4.40
		8	0.34	2.55
		13½	0.28	1.24
Aug. 6	1913	9	0.40	2.67
		11	0.25	1.36
Sept. 4	1913	8	0.30	2.25
		12	1.40	7.00
		11	0.95	5.18
		12	0.35	1.80
		10	0.30	1.80
Oct. 1	1913	16	0.28	1.05
		9	0.42	2.80
		10	0.75	4.50
		8	0.26	1.95
		6	0.13	1.30
		10	0.25	1.50
		6½	0.72	6.66

TABLE 5. RAINFALL STUDIES AT NEW YORK CITY, 1869 TO 1913, BY "UNIFORM-INTENSITY" METHOD

Uniform Intensities from 2 to 70 Min. Duration with Dates of Their Occurrence

2 Min.

Date	Year	Rate
Oct. 11	1871	2.70
July 12	1874	7.80
Sept. 4	1878	6.00
July 12	1880	3.00
May 22	1881	5.10
Sept. 20	1882	3.90
Sept. 23	1882	3.60
Sept. 23	1882	2.40
July 13	1883	1.80
May 31	1887	2.10
Sept. 13	1891	6.90
June 20	1913	7.50
July 1	1913	5.10
July 24	1913	10.50

3 Min.

Date	Year	Rate
Sept. 26	1871	3.00
Oct. 26	1871	3.60
July 5	1872	4.00
July 17	1877	1.60
July 17	1877	2.20
Aug. 5	1878	10.00
Sept. 4	1878	3.00
July 12	1880	8.00
July 12	1880	7.00
July 12	1880	2.40
Sept. 3	1882	2.80
May 21	1883	6.00
Aug. 30	1884	4.40
June 22	1887	4.00
Apr. 2	1889	4.00
May 4	1890	5.00
June 6	1890	5.00
July 3	1891	10.00
July 26	1893	5.60
June 10	1896	6.80
July 5	1901	5.00
July 5	1901	3.00
July 5	1901	4.20
July 28	1902	5.00
Oct. 8	1903	4.60
Sept. 28	1908	4.00
June 20	1913	2.40
July 28	1913	2.40

4 Min.

Date	Year	Rate
Oct. 11	1871	7.50
July 26	1875	2.70
June 15	1882	3.96
Sept. 23	1882	3.00
Sept. 23	1882	2.70
June 6	1883	4.65
June 25	1884	2.40
Aug. 5	1884	2.40
July 30	1889	3.75
June 11	1890	3.15
June 13	1890	2.85
Aug. 23	1891	3.00
June 9	1892	3.66
July 31	1891	3.30
May 27	1895	3.00
Sept. 15	1896	4.50
Aug. 10	1899	7.05
Aug. 12	1900	3.00
June 21	1902	4.50
July 24	1913	4.80

5 Min.

Date	Year	Rate
Aug. 13	1869	5.88
July 10	1878	1.80
Aug. 10	1880	2.88
Aug. 25	1880	1.80
July 13	1883	3.96
Sept. 23	1882	1.44
Aug. 5	1884	4.20
Aug. 30	1884	3.00
July 29	1885	3.48
Nov. 18	1886	3.26
May 31	1887	1.44
June 17	1887	3.36
Aug. 18	1887	4.92
Aug. 21	1887	3.60
Sept. 13	1889	2.40
Sept. 16	1890	2.88
Apr. 23	1891	3.12
Aug. 20	1893	6.00
Oct. 27	1893	3.00
Aug. 3	1894	4.80

5 Min.—Continued

Date	Year	Rate
Aug. 6	1895	5.00
July 12	1896	2.40
May 27	1897	5.28
Aug. 23	1897	1.56
Aug. 24	1898	3.60
July 12	1899	3.00
Sept. 1	1899	6.00
Aug. 5	1902	6.00
Feb. 28	1903	4.08
July 28	1904	3.24
Aug. 9	1907	3.00
Mar. 27	1910	3.24
June 27	1912	4.68
July 28	1913	4.40

6 Min.

Date	Year	Rate
Oct. 26	1871	3.60
Oct. 26	1871	1.90
July 10	1874	2.40
July 10	1874	3.00
May 22	1881	5.00
June 15	1882	3.90
June 25	1884	1.80
June 20	1887	4.10
June 20	1887	2.00
July 21	1889	3.00
Aug. 2	1889	3.00
Aug. 9	1891	2.40
Aug. 20	1893	4.00
July 15	1896	3.00
July 15	1896	3.60
July 22	1896	2.00
Sept. 18	1896	4.70
Aug. 24	1898	2.30
June 28	1899	3.00
Aug. 24	1901	2.00
Oct. 23	1912	2.40
June 20	1913	3.00
July 24	1913	1.50
Oct. 1	1913	1.30

7 Min.

Date	Year	Rate
June 7	1871	4.11
June 27	1873	2.72
Aug. 16	1876	1.02
July 3	1877	3.40
July 17	1877	3.27
July 27	1880	4.29
May 12	1881	4.29
Aug. 7	1881	3.26
Sept. 22	1882	3.00
Aug. 3	1885	1.12
May 31	1887	2.60
Aug. 24	1887	3.00
June 26	1888	3.70
Sept. 12	1888	1.60
June 6	1890	1.80
Aug. 20	1893	4.30
Aug. 20	1893	1.96
Aug. 31	1895	4.30
July 20	1896	2.75
Sept. 1	1897	3.00
July 4	1898	3.93
Sept. 3	1899	3.86
Aug. 25	1900	2.14
Aug. 25	1900	3.86
Aug. 25	1900	3.43
July 5	1901	2.31
Aug. 5	1902	4.28
Aug. 15	1911	2.14
May 27	1906	2.14
Aug. 15	1911	2.14
Mar. 26	1913	3.00
Oct. 1	1913	6.66

8 Min.

Date	Year	Rate
June 21	1869	2.40
July 10	1874	2.02
Aug. 28	1875	3.75
July 12	1877	1.80
Aug. 14	1877	2.25
Aug. 5	1878	3.75
July 12	1880	3.75
Aug. 2	1880	6.00
Sept. 23	1882	1.50
Sept. 23	1882	2.25
July 13	1883	1.88
Aug. 22	1884	3.75

8 Min.—Continued

Date	Year	Rate
June 5	1885	2.63
June 22	1887	1.88
June 15	1889	1.78
June 9	1892	1.80
June 27	1895	1.73
July 15	1896	2.10
July 21	1897	2.93
Sept. 3	1899	2.40
May 19	1900	2.02
July 28	1902	4.04
Aug. 5	1902	2.25
Aug. 19	1902	1.88
June 19	1903	2.62
June 22	1903	3.52
Oct. 8	1903	1.88
May 27	1906	1.42
Aug. 24	1911	1.88
May 30	1912	7.50
July 21	1912	2.25
July 21	1912	1.88
July 24	1913	1.35
July 28	1913	2.46
July 28	1913	2.55
Sept. 4	1913	2.25
Oct. 1	1913	1.95

9 Min.

Date	Year	Rate
June 7	1871	2.22
Aug. 4	1871	1.62
Aug. 21	1873	2.40
Aug. 6	1876	3.33
July 17	1877	3.00
July 10	1878	2.16
June 26	1882	2.67
Sept. 23	1882	1.18
Aug. 2	1884	2.60
Aug. 2	1885	3.33
May 31	1887	3.33
July 19	1888	2.67
Aug. 4	1888	1.86
Aug. 29	1890	1.68
Sept. 16	1890	2.07
June 6	1893	2.73
June 5	1895	4.00
Aug. 4	1895	1.47
June 9	1897	2.10
Aug. 19	1904	1.87
Aug. 13	1905	1.47
Sept. 11	1907	3.27
July 28	1913	1.41
Aug. 6	1913	2.67
Oct. 1	1913	2.80

10 Min.

Date	Year	Rate
Aug. 13	1869	0.42
Aug. 15	1869	2.22
July 25	1870	2.70
July 16	1871	3.00
June 22	1875	2.10
May 22	1876	2.70
Aug. 25	1877	2.58
July 21	1878	2.10
Sept. 11	1882	2.10
Aug. 22	1884	4.60
July 17	1890	2.28
Oct. 10	1890	1.44
Sept. 13	1891	1.80
Aug. 19	1893	3.60
July 20	1894	2.40
Aug. 4	1895	1.02
Aug. 6	1895	1.62
June 21	1896	1.62
July 30	1896	4.00
July 12	1897	1.80
July 17	1901	1.92
July 20	1902	2.10
July 28	1902	3.00
Aug. 19	1902	2.50
June 21	1903	2.28
Sept. 17	1903	1.98
Sept. 14	1904	2.82
July 29	1905	2.10
July 17	1906	3.72
Aug. 15	1911	1.80
Sept. 4	1913	1.80
Oct. 1	1913	4.50
Oct. 1	1913	1.50

11 Min.

Date	Year	Rate
Sept. 26	1871	0.80
Oct. 26	1871	2.73
July 12	1874	1.70
Aug. 25	1879	2.45
Sept. 23	1882	3.00
June 25	1884	1.70
July 12	1884	2.20
Apr. 11	1891	1.64
July 23	1891	2.62
Sept. 5	1891	1.98
June 9	1892	1.64
June 6	1893	3.16
Sept. 16	1894	2.10
Sept. 3	1896	3.82
Aug. 23	1897	3.00
Sept. 1	1899	1.91
July 2	1903	2.40
Oct. 8	1903	2.73
May 30	1904	2.10
June 22	1905	2.45
Sept. 11	1907	1.36
Feb. 27	1912	2.90
July 28	1913	6.30
Aug. 6	1913	1.36
Sept. 4	1913	5.18

12 Min.

Date	Year	Rate
June 21	1869	0.65
July 21	1869	0.90
June 27	1870	2.25
July 16	1871	0.75
Sept. 26	1871	0.60
Aug. 18	1875	1.35
July 11	1876	1.50
Aug. 16	1876	2.50
Aug. 14	1877	1.70
Aug. 5	1878	7.50
Sept. 4	1878	1.20
July 4	1881	2.25
May 21	1883	2.50
May 21	1883	1.65
Aug. 3	1885	1.35
Aug. 4	1888	2.50
June 11	1889	2.00
July 27	1896	1.65
May 24	1897	2.50
Aug. 23	1897	2.25
July 5	1901	2.10
Aug. 24	1901	1.80
July 30	1903	1.75
Oct. 8	1903	1.50
Sept. 14	1904	1.65
May 5	1906	5.00
May 26	1906	1.70
Sept. 4	1913	7.00
Sept. 4	1913	1.80

13 Min.

Date	Year	Rate
Oct. 11	1871	2.12
July 26	1875	4.81
Aug. 22	1882	2.31
June 26	1888	1.85
Sept. 20	1888	3.05
July 30	1889	1.38
Sept. 7	1893	1.94
Aug. 4	1895	1.52
Aug. 31	1895	1.38
Aug. 23	1897	2.17
June 21	1902	1.20
July 28	1902	6.06
Aug. 13	1900	2.21
June 10	1910	2.54
July 20	1911	2.78
Oct. 23	1912	1.38

14 Min.

Date	Year	Rate
Sept. 26	1871	2.10
July 5	1873	1.92
Aug. 1	1878	2.01
June 15	1879	1.28
Sept. 22	1882	1.56
May 29	1888	1.60
July 19	1889	1.33
Sept. 17	1889	2.27
June 17	1891	1.72
Aug. 15	1894	1.40
July 30	1895	1.29
May 28	1896	1.93

14 Min.—Continued

Date	Year	Rate
July 12	1896	2.14
July 6	1901	3.21
July 28	1913	1.24

15 Min.

Date	Year	Rate
Aug. 16	1871	2.00
July 12	1874	0.96
Oct. 4	1877	0.64
Oct. 4	1877	2.00
June 21	1878	1.08
Aug. 1	1878	1.56
Sept. 11	1882	1.60
May 21	1883	1.60
Aug. 4	1888	2.00
Aug. 21	1888	2.00
Aug. 23	1891	1.32
May 3	1893	1.56
Sept. 8	1894	2.88
Aug. 4	1897	1.24
July 5	1901	1.60
July 30	1903	1.44
July 30	1903	1.60
June 28	1909	2.20

16 Min.

Date	Year	Rate
July 10	1874	1.40
Sept. 23	1882	1.32
Aug. 22	1887	1.60
Oct. 7	1893	1.00
June 21	1896	2.62
July 20	1896	1.01
Sept. 1	1897	1.24
July 12	1899	1.12
July 5	1901	2.70
Oct. 8	1903	1.12
July 14	1908	2.70
July 14	1908	1.54
Oct. 1	1913	1.05

17 Min.

Date	Year	Rate
July 19	1882	1.60
Sept. 10	1882	1.41
Aug. 22	1890	1.77
Aug. 5	1891	1.51
Aug. 24	1901	1.20
June 10	1910	1.41
Oct. 19	1911	1.84

18 Min.

Date	Year	Rate
July 16	1871	1.50
July 27	1873	1.13
Aug. 21	1888	1.67
July 29	1903	2.77
Oct. 19	1905	2.00
July 11	1910	2.36
July 1	1913	1.40

19 Min.

Date	Year	Rate
July 9	1877	1.42
Aug. 25	1880	1.41
Sept. 8	1888	1.50
Aug. 13	1889	1.26
June 9	1897	1.36
May 19	1900	1.58
Aug. 19	1904	3.80
Aug. 19	1904	0.95
Oct. 23	1912	1.58

20 Min.

Date	Year	Rate
June 21	1869	0.54
June 21	1869	0.27
July 16	1871	0.45
July 4	1872	1.71
July 31	1878	1.44
Aug. 4	1888	1.14
Aug. 21	1888	1.05
Sept. 17	1890	1.20
Aug. 9	1891	1.50
July 23	1897	2.34
July 28	1897	1.26
Aug. 17	1900	1.29
July 10	1906	1.74
July 21	1912	2.34

21 Min.

Date	Year	Rate
Oct. 4	1877	1.50
July 27	1889	1.50

21 Min.—Continued

Date	Year	Rate
June 13	1890	1.13
Sept. 8	1894	2.50
July 28	1902	1.15
Oct. 23	1912	1.43
Oct. 24	1912	1.26

22 Min.

Date	Year	Rate
July 31	1878	1.37
Sept. 23	1882	1.37
Aug. 30	1884	1.28
Sept. 17	1888	1.28
June 27	1900	1.04

23 Min.

Date	Year	Rate
June 27	1870	1.08
Oct. 4	1877	0.65
June 21	1878	1.51
Sept. 23	1882	1.30
Aug. 22	1887	1.00
July 28	1897	1.10

24 Min.

Date	Year	Rate
Aug. 23	1891	1.90

25 Min.

Date	Year	Rate
Oct. 4	1877	1.20
Sept. 23	1882	1.92
July 31	1888	0.86
Aug. 24	1901	1.63

26 Min.

Date	Year	Rate
Aug. 18	1875	0.95
Feb. 6	1896	1.15
June 14	1903	1.70

27 Min.

Date	Year	Rate
Sept. 23	1882	1.11
May 28	1888	1.31

28 Min.

Date	Year	Rate
June 15	1898	1.36

29 Min.

Date	Year	Rate
June 7	1871	0.27
Oct. 8	1903	1.78

30 Min.

Date	Year	Rate
Nov. 27	1878	1.00
July 4	1889	0.90
June 8	1900	1.20

31 Min.

Date	Year	Rate
June 21	1896	1.84

32 Min.

Date	Year	Rate
Aug. 21	1888	0.75
June 11	1910	0.94

33 Min.

Date	Year	Rate
June 29	1903	0.73

35 Min.

Date	Year	Rate
Aug. 21	1888	0.86
July 27	1889	0.75
June 22	1905	1.83
Sept. 28	1908	0.77

36 Min.

Date	Year	Rate
Sept. 4	1878	1.33

40 Min.

Date	Year	Rate
June 28	1909	1.26
Aug. 24	1911	1.17

47 Min.

Date	Year	Rate
Oct. 9	1903	1.36

54 Min.

Date	Year	Rate
Aug. 24	1907	1.22

60 Min.

Date	Year	Rate
July 25	1872	1.00
July 30	1889	1.00
May 30	1904	0.87

66 Min.

Date	Year	Rate
Aug. 23	1893	1.00

70 Min.

Date	Year	Rate
July 21	1877	1.00

occurred twice, the 15-yr. curve three times, etc., *even if all of the storms had occurred in the same year.* The dates of the storms used to construct these curves are usually omitted, and like the averages of which they are formed must be taken on faith. I have supplied these missing dates, however, and have thereby given an opportunity to study the reasoning upon which the curves are based. Of the 99 points through which the nine curves covering the whole 45 yr. are drawn, *25 occurred within 65 days in the year 1913,* 57 in the last 15 yr. and only 42 in the preceding 30 yr.

Again, overlooking these facts, these curves represent maximum rainfalls that are supposed to re-occur in a certain interval of years. They are obtained by dividing the total period observed by the number of times certain rates occurred in that period. This gives a definite result that must either be substantially right or totally wrong. If it is correct, it should coincide with a similar curve based on any period of observation.

In doing this work the writer began with only 25 yr. of rainfall observations, and the rainfall curves produced from a 25-yr. period by this method varied widely from those he obtained later from a 45-yr. period; and it is safe to predict that curves based on 60- or 100-yr. observations would vary widely from both.

Again, these curves should be an average of maximum storms for their designated periods. Let us take the 15-yr. period for an example. In the 45 yr. under dis-

cussion there are *thirty* 15-yr. periods, the first from 1869 to 1883, the second from 1870 to 1884, etc. What relation does the 15-yr. curve bear to the storms in all of these 15-yr. periods? Obviously, none whatever. The same reasoning will apply to all the other curves.

Rainfall curves constructed in this way of misleading "average rates" are not a safe guide for designing engineering work. Not only does the theory upon which they are based seem illogical, but an examination of the facts does not bear out any of its assumptions.

The "average-rate" method for the 45 yr. examined provides 934 intensities above the adopted minimum for 11 periods beginning at 5 min., very few of which actually occurred, while the "uniform-intensity" method, recorded

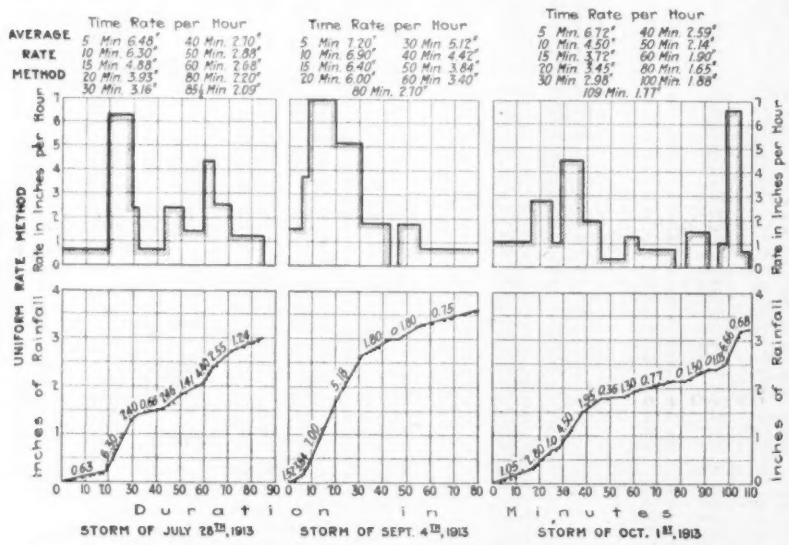

AVERAGE RATE METHOD
Time Rate per Hour
5 Min 6.48" 40 Min. 2.70"
10 Min. 6.30" 50 Min. 2.88"
15 Min. 4.88" 60 Min. 2.68"
20 Min. 3.93" 80 Min. 2.20"
30 Min. 3.16" 85½ Min. 2.09"
Time Rate per Hour
5 Min. 7.20" 30 Min. 5.12"
10 Min. 6.90" 40 Min. 4.42"
15 Min. 6.40" 50 Min. 3.84"
20 Min. 6.00" 60 Min. 3.40"
80 Min. 2.70"
Time Rate per Hour
5 Min. 6.72" 40 Min. 2.59"
10 Min. 4.50" 50 Min. 2.14"
15 Min. 3.72" 60 Min. 1.90"
20 Min. 3.45" 80 Min. 1.65"
30 Min. 2.98" 100 Min. 1.88"
109 Min. 1.77"
UNIFORM RATE METHOD
Rate in Inches per Hour
Inches of Rainfall
Duration in Minutes
STORM OF JULY 28TH, 1913
STORM OF SEPT. 4TH, 1913
STORM OF OCT. 1ST, 1913

FIG. 5. STORMS OF JULY 28, SEPT. 4 AND OCT. 1, 1913, AT NEW YORK CITY

with equal care from the same storms, finds only 394 for 37 periods of 5 min. and over, every one of which records an actual occurrence. An examination of the diagrams and tables will disclose some other significant variations. The first shows 280 intensities of over 30 min. duration, the second only 18. The first gives 50 of 80 min. duration and over and the second only one as high as 70 min. Fig. 4 (uniform intensities) will also show that 94% of them have a duration of 25 min. or less and that only 4% exceed 30 min. in duration.

Another test of the rainfall curves of the "average-rate" method is furnished by an examination of Fig. 4. It will be seen that I have affixed dates to 64 of the highest intensities of a duration of 5 min. and over. Arranging these dates by years, we find that 17, or 26½%, occur in the first 22 yr. between 1869 and 1890 and that 47, or 73%, occur in the following 23 yr. between 1891 and 1913, which demonstrates that dividing the whole period of 45 yr. by the number of occurrences to find average frequencies is unwarranted.

Whatever value the "average-rate" method of compiling rainfall data has, is confined to recording the maximum quantity of rain that accumulates in certain periods, but deductions based on a factitious "average rate" computed from such an accumulation must prove fallacious, even if the averaging in the other stages of the method were justified.

In the compilation of "uniform intensities" given here the writer has confined himself closely to every noticeable variation of the rate. While this is the most consistent way, it is well to remember that very short periods with high precipitation give very high rates per hour and consequent high points in the rate diagram. Now it is well known that very high intensities for short periods are apt to be confined to small areas and may not affect the whole drainage area. Nor is it certain that the high intensities even for the longer periods begin and end over the whole area at the same time. Unfortunately there are no data on which the area covered by the storms can even be estimated.

A further study of the subject of uniform intensities may disclose that certain lower intensities for very short periods preceding and following the higher ones may be added in certain cases, resulting in slightly lower rates and a corresponding slight increase in duration. An interesting study by Professor Weyrauch in the *Gesundheits Ingenieur* for March, 1912, discusses the problem without, however, giving a final determination. Whether future investigations will result in formulating a generally applicable rule, I doubt; but with an intelligent use of the records, "uniform intensities" will furnish safer guides to the engineer than the system of complicated "average rates." This reference to a departure from a hard-and-fast application of the rule must not be assumed, however, to be an approach to the old system, but is an attempt to eliminate unnecessary refinement and a dogmatic precision from a subject as variable as thunder storms and to apply the axiom "that no computation need be more accurate than the data upon which it is based."

While the writer must dissent from the application of the unsound "average-rate" theory, he regrets that at present he can offer no substitute other than the primitive one of examining the rainfall diagrams that show the actual frequency of high intensities and from them selecting the storms that in the engineer's opinion should be carried off by the sewers he intends to design. This will of course require some study of the rainfall and good judgment in applying the knowledge gained, but will have the advantage of being based on simple facts without the interposition of any theory. Nor does such a study involve the expenditure of more time than is warranted in the construction of a drainage system where a consideration of the rainfall is necessary.

In order that the two methods may be compared and also that adherents of the "average-rate" method may find this compilation useful the data have been carefully presented in both ways. But whichever method is followed, one important question will remain to be answered after the frequency of certain intensities is determined. What frequency shall be provided for? Shall storms that occur once in 20 yr., once in 10 yr. or that occur every year be the measure, or will some other rule than "the relation of original cost to probable damage from flood" be more broadly economical? Here the theorists of the old school have another *pons asinorum* that may have to be rebuilt in the near future.

Overturning Stringers Cause Highway-Bridge Failure

By D. A. Thomas*

The Michigan State Highway Department was recently called upon to inspect an interesting bridge failure caused by the failing of the stringers in one panel, which turned over and buckled under the weight of a traction engine, permitting the engine to drop through into the river. Had the stringers remained upright, the engine would have undoubtedly crossed in safety, although a subsequent computation of the stresses showed that the floor system would be 30% overloaded with a 10-ton traction engine—the size of the engine which caused the failure. Three of the stringers in the panel adjoining the one which the engine went through were turned down through part of their length (see accompanying illustration).

The bridge, which is typical of many old highway bridges, is of the through Pratt type and was erected in 1880. It has six panels 14 ft. 8 in. long, making a total span length of 88 ft. The roadway is 14 ft. wide. The

STRINGERS OF HIGHWAY BRIDGE TURN OVER

floor stringers are five lines of I-beams and two lines of channels, all 5 in. deep, spaced 2 ft. 4 in. apart. The floor-beams are of quite heavy section, 10¾ in. deep. The floor planks, laid directly upon the stringers, are not fastened to them.

The cause of the turning of the stringers may be traced to some movement of the engine which had a tendency to cause a sidewise motion, due in part, perhaps, to the fact that the floor planks were not fastened down. It should not have been possible for the stringers to turn over, however, had they been properly attached to the floor-beams. The stringers were secured to the floor-beams by but one bolt through the flange at each end, and both bolts were on the same side. Thus comparatively little resistance to overturning was offered in one direction.

In the report on the failure the State Highway Department advised that the present stringers be replaced by seven lines of 7-in. 15-lb. I-beams and that the following preventive measures be taken to guard against the repetition of a similar failure: First, the stringers should be bolted to the floor-beams by two bolts at each end, one on each side of the web, and connected by fishplates; second, furring strips should be attached to the stringers, and the floor planks nailed to these.

*Michigan State Highway Department, Lansing, Mich.

Cost of Testing Road-Building Materials; New York

So few data exist on the cost of testing construction materials that the accompanying table and explanations from the 1915 report of Henry E. Breed, Deputy Commissioner of Highways of New York, are noteworthy.

The New York State Highway Department Bureau of Tests is divided into three divisions—a physical testing laboratory, which makes field examinations and laboratory tests of stone, gravel, slag, cement, sand and concrete; a chemical laboratory for testing asphalts, tars, paints, oils, brick, etc.; and an office of record, which compiles and tabulates records of tests of both laboratories for use in the Highway Department.

During the year 1915 the physical laboratory tested and examined the following number of samples: 947 samples of stone; 973 samples of sand and gravel; 1,444 concrete cubes; 867 samples of cement, which represented 846,317 bbl. of cement. For sand testing, 2-in. mortar cubes are now used, being broken at 7 and 28 days.

Concrete Cubes of Field-Made Concrete

Making 6-in. concrete cubes in the field and testing them in the laboratory have proved valuable in determining more accurately the quality of the concrete in the work. The following tabulation of the 1,444 test cubes is given to show the average results obtained:

Concrete Mix	Average Compression, Lb. per Sq.In.	Number of Cubes
1 : 1½ : 3	3,620	796
1 : 2½ : 5 (crushed stone)	1,935	222
1 : 2½ : 5 (gravel)	1,755	200
1 : 2½ : 5 (all cubes)	1,875	474
1 : 3½ : 4 1 : 3 : 4½ (mostly slag)	2,140	56

Cubes failing below 3,000 lb. per sq.in. for 1 : 1½ : 3 concrete and 1,800 lb. per sq.in. for 1 : 2½ : 5 concrete were considered below the desirable grade. There were 10.95% of these in 1915. All cubes showing a breaking strength below 3,000 lb. per sq.in. were carefully inspected to determine to what the low strength was due. Any of them which showed indications of carelessness in mixing were returned to the division office with laboratory comments.

The following is a tabulation of the low-strength cubes during 1915 and reasons which seemed to have caused the low breaking strength, with percentage of the whole number of cubes:

Cause of Low Break	%
Sand dirty, containing loam and also dirt from subgrade	35.4
Stone or gravel coated	35.0
Sand too fine	8.5
Poor quality of stone or gravel	8.2
Poor manipulation in making cubes	4.7
Lack of proper mixing	3.5
Miscellaneous, too wet, etc.	4.7

All concrete cubes previous to 1915 were tested 28 days after casting. This period was chosen because comparative data were available on compression for concrete at this age. During 1915 enough cubes were broken at an age of 7 days to give sufficient data to be able in future to judge the quality of the material when broken at this age.

Tests of Paving Brick

There were 269 lots of paving brick submitted for test, representing 22 different brands, or approximately 27,000,000 brick. Each sample consisted of 30 brick, representing hard, medium and light burned brick. These different grades of brick were tested separately, and the

results obtained served as a guide in culling where culling was necessary.

The brick were subjected to the following tests: (1) General inspection to cover burning, kiln marks, size, lugs, grooves, etc.; (2) abrasion tests (each test on 10 brick); (3) modulus of rupture or cross-breaking (10 brick being broken); (4) absorption (5 brick being used). Of the 538 abrasion tests made 73, or 13.6% of the brick tested, failed to meet the standard required by the specifications. There were 269 tests (each on an average of 10 brick) made for cross-breaking strength. Of these 269 tests 14 tests, or 5.3% of the brick, failed to meet the required standard. Of the 269 absorption tests (each on an average of 5 brick) 4 tests, or 1.5%, failed to meet the required standard.

Tests of Bituminous Materials

Under the head of bituminous materials there were 1,368 samples tested during 1915. According to the type of construction under which they were used, these materials and the quantities represented were classified as follows:

	Samples	Gal.
Asphalt:		
Type No. 1	23	334,219
Type No. 2	27	357,948
Penetration	473	8,028,730
Tars:		
High-carbon binder	187	1,278,282
High-carbon hot application	33	181,536
High-carbon cold application	345	2,630,328
Low-carbon binder	4	23,087
Low-carbon hot application	10	25,462
Low-carbon cold application	32	205,405
Paving pitch	11	16,750
Hot application oil	35	342,914
Cold application oil	188	2,571,981
Total		15,996,642

The other materials tested included glutrin, crude tars, rocmac, mixed paint, motor-cylinder oil, premolded joint and miscellaneous oils.

TABLE OF UNIT COSTS OF TESTING SAMPLES OF ROAD-BUILDING MATERIALS, NEW YORK STATE

Distribution	Analyses, Oils and Asphalts, Asphalt Blocks, Paints, Etc. 1,748 Samples	Brick, 269 Samples	Cement, 867 Samples	Concrete Cubes, 1,444 Tests	Sand and Gravel, 973 Samples	Stone, 947 Samples
Laboratory work	$3.36	$5.13	$3.06	$0.49	$2.80	$1.88
Fieldwork inspection	2.67	...	7.44	...	...	...
Office work	.80	2.57	.97	.30	1.26	.91
Total cost per test of sample	$6.83	$.770	$11.47	$0.79	$4.06	$2.79

Hydrated Lime Pays at Council Bluffs Settling Basins

By J. B. Thornell*

The use of hydrated lime at the settling basins of the Council Bluffs water-works as an aid to aluminum sulphate in the coagulation of suspended matter in the water was commenced in February, 1915.

The snowfall in the Missouri River valley during the winter of 1914-15 was very heavy and it lay on the ground until late in February. Then came a sudden rise in temperature and several days of drizzling rain. A large volume of soft water was suddenly thrown into the river, flushing the ground and carrying with it much vegetable matter and silt and many bacteria. The alkalinity of the river water was reduced 50% and the organic content increased 300%. A marked reduction in the alkalinity and increase in the organic content and turbidity of the river water occurs every spring, but so great and so sudden a change as that of 1915 is very unusual.

The low alkalinity and the presence of the organic matter were immediately shown in the action of the alum solution used as coagulant, or rather in its failure to

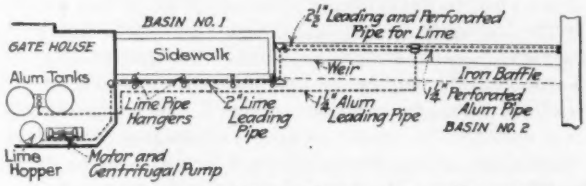


FIG. 1. SKETCH PLAN OF LIME AND IRON PIPES, COUNCIL BLUFFS SETTLING BASINS

act as it should. The alum, instead of forming a flocculent precipitate of aluminum hydroxide, was combining with the organic matter in the water and passing on through the settling basins in solution. In other words, little or no coagulation was taking place. The suspended matter in the water was exceedingly fine and very little of it was removed by natural sedimentation. The tap water became very turbid. The fine particles of suspended matter carried bacteria and it became necessary to add an excess of calcium hypochlorite to make sure

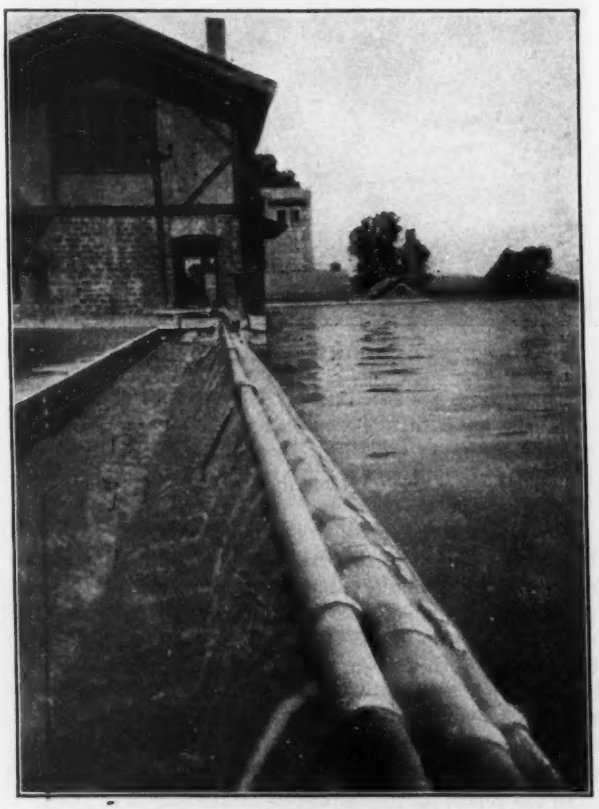


FIG. 2. VIEW OF LIME AND ALUM PIPES, COUNCIL BLUFFS SETTLING BASINS
Lime pipe on right, alum pipe on left, discharging in opposite directions

that no harmful bacteria were being carried into the mains.

It was decided to use hydrated lime to assist the alum in removing the turbidity. Temporary apparatus for this purpose was installed as quickly as possible. The apparatus was crude and it was impossible under the

*Chemist in Charge of Water Treatment, Council Bluffs, Iowa.

RESULTS WITH ALUM ALONE AND WITH LIME AND ALUM AS COAGULANTS, COUNCIL BLUFFS WATER SEDIMENTATION BASINS

Month	Suspended Matter — Parts per Million: Raw Water	Basin No. 1‡	Tap	Total Bacteria*: Raw	Settled§	% Removed **	Presumptive Test for B. Coli† (% Positive): Raw	Settled	Coagulants Used (Grains per Gal.): Alum	Lime	Cost of Coagulants per 1,000 Gal. Treated‖: Actual	Based on 1914 Alum Price
1914												
April	2,345	1,271	6.9	27,440	1,017	96.4	80	41	2.3	0	$0.0032	$0.0032
May	3,458	1,175	5.4	54,041	1,291	97.7	100	100	2.9	0	.0040	.0040
Average	2,901	1,223	6.1	40,740	1,154	97.0	90	70.5	2.6	0	.0036	.0036
1916												
April	3,400	2,223	1.7	40,270	329	99.2	100	50	2.4	1.1	.0048	.0038
May	3,200	945	1.0	16,000	490	97.0	100	0	1.3	1.3	.0029	.0024
Average	3,300	1,584	1.4	28,135	409	98.1	100	25	1.9	1.2	.0039	.0031

* Nutrient agar, room temperature, 72 hr.
† Lactose broth, 37° C., 48 hr.
‡ Samples taken at weir at point of application of lime and alum.
§ Clear water samples taken just before treatment with sterilising reagent.
‖ Cost of alum per 1,000 lb.: 1914, $9.75; 1916, $12.50. Cost of lime, 1916, $3.50.
** By coagulation and sedimentation combined, but not including chlorination.

conditions then existing to make the application of the lime in the place where it would do the most good. The only way in which it could be applied at that time was to inject the lime solution into the intake pipe of the low-service pumps that lift the water from the river into the settling basins. There were two disadvantages in applying it at this point. First, it was too far from the point where the alum solution was applied, and second, the lime was going into the water before any of the heavier suspended matter (sand and mud) had settled out.[1]

The application of lime in the suction of the low-service pumps brought the turbidity of the tap water down to the zero mark within two weeks and did very effective work during the high-river stage; but, under the conditions described, it was necessary to use about twice as much lime as would have been required with better means of applying it. The use of lime, therefore, was discontinued about July 15, and our attention was turned to contriving better apparatus for carrying the lime solution to a more advantageous point of application. This was effected after several months of experimenting.

The lime solution is now added to the water through a perforated pipe extending over the entire length of the weir between the first and second settling basins. (See sketch plan, Fig. 1, and view, Fig. 2.) The water flows over this weir, which is 45 ft. long, in a sheet about 3 in. deep. The alum solution is added in the same manner immediately after the lime solution, the two lines of application being only about 18 in. apart. The water then passes through an iron baffle and into the second basin.

The lime-feeding apparatus is located in the gate-house near the weir. The lime is placed in a large iron hopper in the bottom of which is a worm that feeds the dry lime into another smaller hopper below, where it meets a stream of water and is carried out through a 2-in. pipe to the weir. The feeding device is driven by a small electric motor and is so constructed that it can be run at six different speeds, according to the amount of lime required. The same motor that drives the feeding device also drives a small centrifugal pump that draws from one of the settling basins the water needed to dissolve the lime and carry it to the weir. A large volume of water is used with the lime so that it is carried to the weir completely dissolved and not as a sludge. The use of plenty of water with the lime is important as it not only prevents clogging of the feed-pipes, but it also brings about more uniform and thorough mixing with the water before it comes in contact with the alum solution.

The amount of lime used is varied with the condition of the raw water. During April and May, 1916, it ranged from 0.5 to 1.5 grain per gallon of water treated. The amount of alum required varied between 1 and 3 grains per gallon. During this period the average turbidity of the raw water was 3,300 p.p.m. and the turbidity of the water at the point of application of the lime and alum was 1,584 p.p.m.

The accompanying table shows the comparative results in the removal of suspended matter and bacteria by the coagulants in April and May, 1914, and in April and May, 1916. The year 1914 is taken for comparison because no hydrated lime was used at that time and the condition of the river water was very nearly the same then as two years later.

The number of bacteria and the percentage of positive tests for *B. coli* in the settled water have been considerably lowered since hydrated lime was put into use. With the use of alum alone as the coagulant it seemed almost impossible to remove all the suspended matter. A barely visible smokiness remained in the tap water most of the time—even when the alum was working at its best. That this suspended matter carried bacteria is seen in the column showing total bacteria in the settled water. The water, after clarification, is further treated with liquid chlorine for the removal of bacteria. It is obvious, however, that the increased removal of bacteria, especially those of the colon type, which has been brought about by the use of lime in clarification has greatly lessened the chance for harmful bacteria to enter the mains.

The last column shows that the use of lime with alum is more economical than the use of alum alone.

We regard our experience with the use of hydrated lime as highly satisfactory. We have obtained treated water, the sanitary and esthetic qualities of which were much better and the cost of which was less than could have been procured by the use of alum alone. The main factors in the success of the treatment are:

1. Natural sedimentation before the addition of coagulants.
2. Points of application of lime and alum solutions near together—but far enough apart to allow thorough mixing of the lime solution with the water before receiving the alum.
3. Uniform feed of the lime and alum solutions.
4. Thorough baffling of the water immediately after application of the coagulants but not too violent agitation.
5. Large volume of water to carry the lime.
6. Constant care in determining the amounts of lime and alum required.

[1] In regard to this second point, we have found by experiment and actual experience that the effectiveness of lime and alum in removing suspended matter from the Missouri River water is more than doubled by allowing the heavier matter (which usually amounts to about 70% of the total suspended matter) to be removed by natural sedimentation—that is, before the addition of coagulants.

Field and Office

Spotting Fires in 29 Miles of Wood Snowsheds

The Southern Pacific Ry. has nearly 28 mi. of continuous snowshed on its line over the summit of the Sierra Nevada Mountains, between Blue Cañon and Truckee, Calif., just west of the Nevada state line. The elevation of Blue Cañon is 4,700 ft. and that of the eastern end of the sheds near Truckee is 6,000 ft. The average annual snowfall in this zone exceeds 200 in.

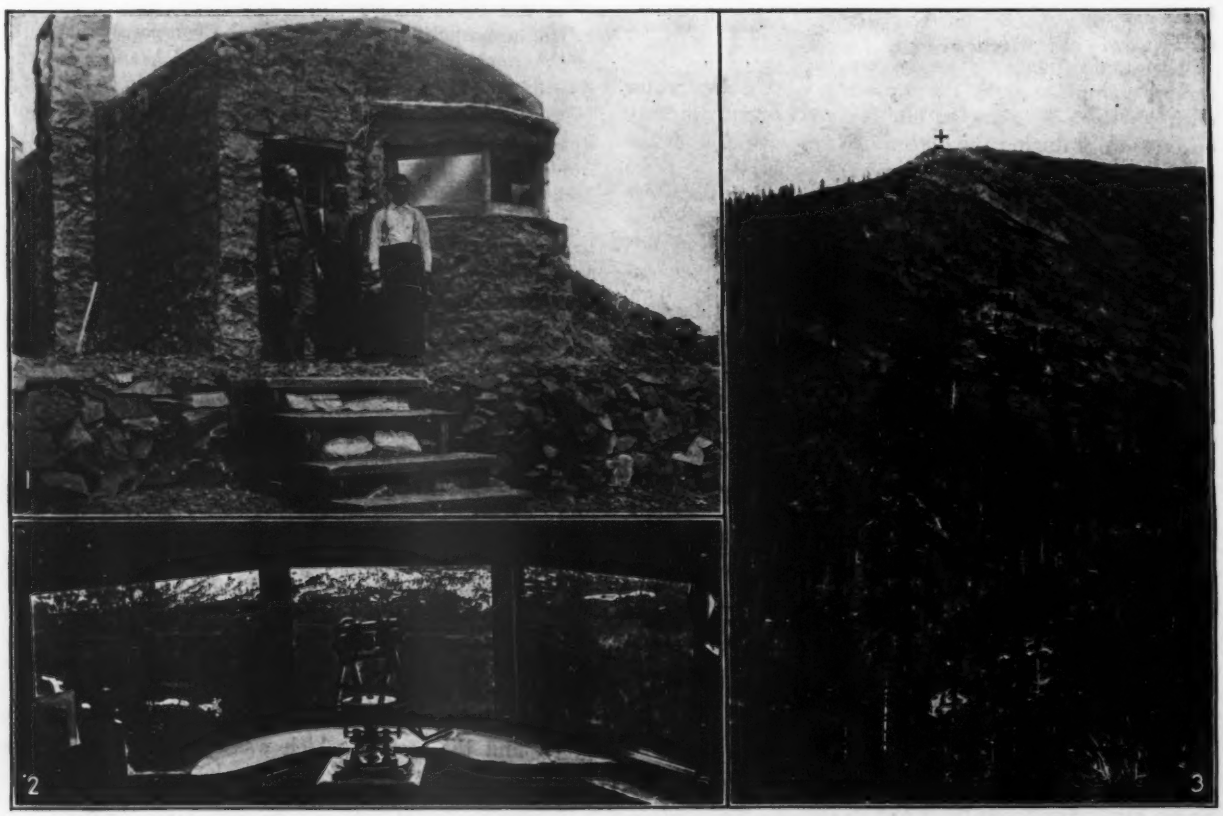
There are 29 mi. of snowsheds in all, one mile being in detached sections 130 to 1,500 ft. in length. The present distribution of the sheds is 77% west and 23% east of the summit. These are all wooden sheds and represent an investment of 97 million feet, board measure, of rough pine lumber, valued at $2,326,000.

During the summer season there is a period of nearly five months with no rainfall, hence the fire hazard is great and the railway has sustained large losses. Fire-fighting trains have been in service since 1870. At present the sheds are protected by four fire trains, located one at each end and two at points of vantage in the shed. Each of these trains consists of a standard 10-wheel locomotive and two water cars. Each engine carries a duplex fire pump of 300 gal. per min. capacity, and an inspirator of 100 gal. per min. capacity. The total water-supply of each train is 20,000 gal. Each train has 1,000 ft. of 2½-in. fire hose.

Unique Fire-Alarm System

A mountain top—the summit of Red Mountain—7,860 ft. high, was selected for an observatory. The mountain is on the north side of the main cañon, while the railway winds about on the south side about 1,800 ft. below, so that with the exception of two points in near parts of the shed, which are cut off from view by intervening mountain tops, the whole of the line of the shed is visible from the observatory. The two hidden parts are watched from another observatory.

To readily locate the position of any fire or suspicious smoke a surveyor's transit is mounted on a fixed pier in the center of the bay window of the observatory. On a shelf in front of the instrument is a silver-coated copper plate on which the line of the shed is shown



FIRE-PROTECTION OBSERVATORY FOR 29 MILES OF SNOWSHEDS ON THE SOUTHERN PACIFIC RY. IN CALIFORNIA
Fig. 1—Outside of observatory. Fig. 2—Looking out through the observation window. Fig. 3—The observatory as seen from the railway

in black. The station points, tunnels, mileposts, signal boxes, etc., are shown on this plate.

Attached to the transit's lower plate is a bracket carrying a knife-edge pointer, which, when the transit is pointed to some station on the shed, intersects the corresponding station on the copper-plate map. The map was constructed in place, the transit and pointer being used to fix the desired points. The sheds are not shown on the map as the arc of a circle, which would answer were the track on a tangent, but are shown as they appear in perspective from the window, for the line doubles back on itself in a number of places.

The copper plate was first covered with wax and knife-marks were scratched on, as were the station numbers and lettering. The marks were then etched with dilute nitric acid. When the wax had been removed the etchings were trued with an engraver's tool and the entire plate was silver-plated, but not polished, so that it has a clear, white mat surface. The plate was then painted with transparent lacquer, the marks having been filled with colored enamels. The whole is protected from scratches by a plate-glass cover.

Where the line of collimation in following the line of the shed cuts the plate-glass window of the observatory in front of the instrument, a line was etched on the window glass, so that the observer may readily follow the line of the shed in the darkness or twilight. At night a small battery-operated electric light is turned on, which illuminates the map, and the reflection on the plate-glass window makes visible the etched line and the cross-hairs of the instrument, so that it is easily possible to set the instrument on a fire, or other light.

The milepost and location of any fire are telephoned to the points where the fire trains are stationed. The scheme has worked to such perfection that a tramp's camp-fire 18 mi. from the observatory has been spotted, as also was a forge fire which a foreman was using to sharpen drills. This fire being apparently in the shed, the fire train was called, ran 2 mi., and stopped exactly opposite the forge, which of course was outside the shed. In the case of an actual fire in the shed, or an exposure fire of magnitude, when fire trains are called, the ones nearest the fire go to the reported scene, and the others close in as in regular fire-department service.

The photographs and data for this article were furnished by Niles Searls, general fire inspector of the Southern Pacific Railway Co., San Francisco, Calif.

Stopping Underground Leakage from a Power Dam

In the construction of a power dam crossing Black River at Black River Village, N. Y., it was found that a considerable quantity of water was lost by underground diversion, the water flowing out of the pond through a gully located a few hundred feet upstream from the dam. There is a second dam across the Black River at a point about one mile downstream. Between these two, the river is of crescent shape, bowing outward to the north, as shown in the accompanying sketch (Fig. 1). Extending in an irregular curved line from the gully described to a point just above the lower dam, is a series of sink holes averaging about 20 ft. in depth. Trenton limestone, the underlying rock formation, is in nearly horizontal beds and lies near the surface.

About 100 ft. upstream from the lower dam is the mouth of an underground channel, through which a

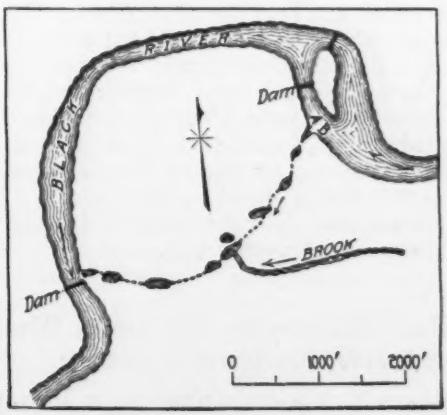


FIG. 1. COURSE OF NATURAL UNDERGROUND CHANNEL ON BLACK RIVER

considerable volume of water entered the pond above the lower dam, this quantity being estimated roughly at 15 to 25 cu.ft. per sec. in high water. A small stream coming off the hills from the southeast drains into one of the sink holes. Apparently the water lost from the pond above the upper dam traverses an underground channel, following approximately the route indicated by the dotted line on the sketch. The water can be seen flowing across the bottoms of the sink holes in various places.

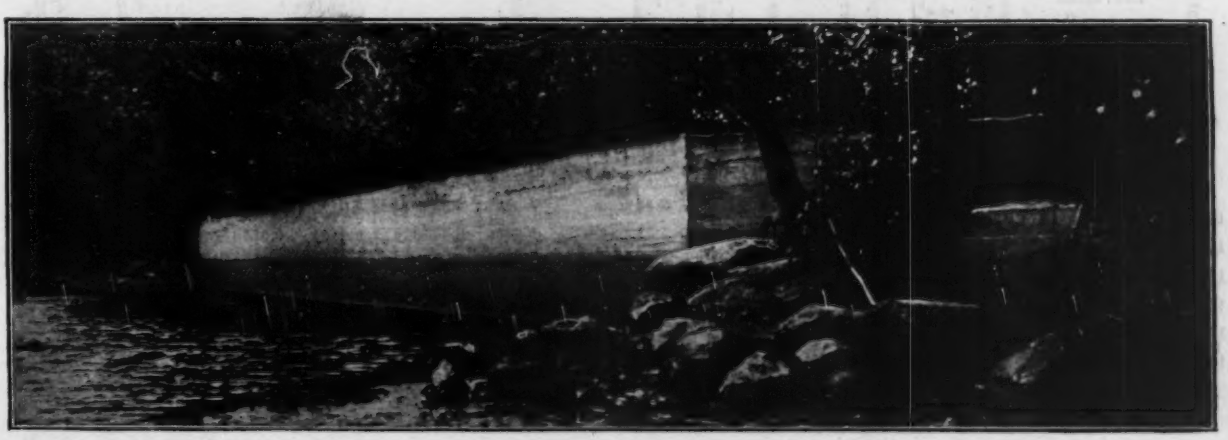


FIG. 2. VIEW OF DAM BUILT TO STOP DIVERGENCE FLOW

FIG. 3. BOTTOM OF ONE OF THE SINK HOLES

Under the conditions described the lower dam caught all of the water of the river but the upper dam lost an appreciable volume. To prevent this loss of water and power, a concrete wall was constructed across the head of the gully at *AB* (see sketch). The length of the wall is about 180 ft.; top thickness 1 ft.; average height, 8 to 10 ft. Considerable difficulty was experienced in stopping the underground flow. However, the work was finally successful and subsequently the outflow of the underground channel above the lower dam has diminished, being now an amount about equal to the inflow from the stream tributary to one of the sink holes.

The work was done under the direction of S. A. Staege, consulting engineer, Watertown, N. Y.

Old Brick Intake Tunnel Shows Low Kutter Factor

By Dabney H. Maury* and Robert E. Horton†

Owing to rapid growth in population and increase in water consumption of Detroit, it recently became desirable to determine the quantity of water which the present main intake tunnel could deliver from Detroit River to the receiving basin and other shore works at the pumping station, under different conditions.

*Consulting Engineer, Chicago, Ill.
†Consulting Hydraulic Engineer, Albany, N. Y.

The tunnel is a brick ring with walls 18 in. thick. It was constructed in 1895; its character can be seen from the accompanying view. It extends for a length of 3,160 ft. into Detroit River, the depth of the center being 63 ft. below mean river level. Water enters the tunnel through an intake crib having numerous inlet ports; the interior diameter of the crib is 37 ft. There is a right-angled bend in the tunnel underneath the crib, a vertical pipe rising 40 ft. from the center of the tunnel and about 9 ft. above the bottom of the crib. The water enters a similar vertical shaft near the shore,

DETROIT WATER-WORKS INTAKE TUNNEL DURING CONSTRUCTION, 1895

and in testing the capacity of the tunnel, water level readings were taken in the center of the crib and in the shore shaft, respectively. The total head losses involved between these two points were those for 3,160 ft. of horizontal tunnel, and for the two vertical shafts (making the total length of 10-ft. tunnel 3,245 ft.)

RESULTS OF CAPACITY TESTS OF DETROIT WATER-WORKS INTAKE TUNNEL (MAURY AND HORTON)

Time, Apr. 3, 1916 (1)	Mean Water Elevation: In Crib (2)	Mean Water Elevation: In Shore Shaft (3)	Gross Head, Ft. (Means in Brackets) (4)	Recorded Pumpage Rate, Cu.Ft. per Sec. (5)	Net Pumpage Rate, Cu.Ft. per Sec. (6)	Storage Change, Cu.Ft. per Sec. (7)	Net Flow in Conduit, Cu.Ft. per Sec. (8)	Mean Velocity, V, Ft. per Sec. (9)	$3.5\frac{V^2}{2g}$ (10)	Net Friction Head, Ft. (11)	Slope, S (12)	$\sqrt{S}$ (13)	$\sqrt{RS}$ (14)	C (15)	Value of "n" for Averaged Heads (16)	Value of "n" for Averaged Pumpage (17)
A.M. 8:30				280.3	271.9	—26.25										
9:00	94.27	92.84	1.43													0.0156
			[1.465]	285.3	276.7	—30.90	245.8	3.13	0.532	0.933	0.000288	0.0170	0.0270	116	0.0152	
9:30	94.28	92.78	1.50													0.0145
			[1.50]	286.4	277.8	—16.96	260.8	3.32	0.598	1.002	0.000310	0.0176	0.0280	119	0.0148	
10:00	94.25	92.75	1.50													0.0132
			[1.515]	285.8	277.2	—1.54	275.7	3.51	0.672	0.843	0.000260	0.0161	0.0256	137	0.0130	
10:30	94.21	92.68	1.53													0.0129
			[1.58]	281.4	273.0	—1.54	271.5	3.46	0.651	0.929	0.000287	0.0169	0.0269	129	0.0137	
11:00	94.25	92.62	1.63													0.0142
			[1.63]	269.7	261.6	0	261.6	3.33	0.602	1.028	0.000317	0.0178	0.0283	118	0.0150	
11:30	94.26	92.63	1.63													0.0147
			[1.615]	259.7	251.9	+9.25	261.2	3.33	0.602	1.013	0.000312	0.0177	0.0281	118	0.0150	
12:00	94.27	92.67	1.60													0.0141
P.M. 12:30	94.28	92.77	[1.555]	262.0	254.1	+13.88	268.0	3.42	0.637	0.918	0.000284	0.0168	0.0267	128	0.0138	
			1.51													0.0142
			[1.48]	263.1	255.2	+3.08	258.3	3.29	0.588	0.892	0.000273	0.0166	0.0264	125	0.0141	
1:00	94.27	92.82	1.45													0.0136
			[1.445]	264.2	256.3	+3.08	259.4	3.31	0.595	0.850	0.000262	0.0162	0.0258	129	0.0136	
1:30	94.26	92.82	1.44													
														Mean	0.0142	0.0141

together with the losses due to velocity and entry head and to two right-angled turns at the junctions of the vertical shafts with the horizontal conduit. In reducing the results, an allowance equal to the velocity head was made for each of the right-angled bends, and one-half the velocity head for the loss at entry, making the total losses, other than friction in the conduit itself, 3.5 times the velocity head. The quantity of water flowing through the tunnel during the tests was determined from the pump-displacement records, with allowance for gain or loss of storage in the receiving basins. The outflow from the pumps passes through venturi meters and the slip of the pumps had been determined and found to be 3%, which allowance was accordingly made in utilizing the pump-displacement record.

The conditions were, it is believed, unusually favorable for the accurate determination of the coefficient of roughness in a submerged water-works tunnel such as are in quite common use for the purpose of deriving water supplies from the Great Lakes, and their connecting channels. The tests were divided into nine periods of ½ hr. each, and the coefficient of roughness was determined for each period. The resulting values of the coefficient n in the Kutter formula are contained in the accompanying table. Two individual computations of the results were made, in one of which the gage readings taken at the beginning and end of a chosen half-hour period were averaged and used in conjunction with the measured pumpage rate for the half-hour period, the resulting values of n being shown in column 16 of the table. In the other method of computation, the pumpage rate for two consecutive half-hour periods was averaged and used in conjunction with the gage readings taken on the even hour or half hour. The values of n determined in this way are shown in column 17 of the table. The two sets of values substantially agree and the coefficient of roughness as determined from the tests ranges from 0.0130 to 0.0152, the mean value being 0.0142.

The tests were carried out, under the direction of the authors as consulting engineers, by T. A. Leisen, General Superintendent, and H. B. Keeney, Engineer of the Water Board.

Supply Main Sustains Capacity for 28 Years

Tests recently made to determine the capacity of the supply main of the village of Malone, N. Y., leading from the intake to the distribution reservoir showed the capacity after 28 years' use to be fully equal to that of a new well-laid conduit of the same size.

The original conduit is of 10-in. cast-iron pipe, laid up hill and down, with numerous deflections, a total length of 35,500 ft. from the intake on Horse Brook to the distribution reservoir at Pinnacle Hill. The upstream 13,000 ft. of the conduit was subsequently paralleled with 12-in. pipe. A booster pumping station was placed at the low point of the 10-in. line, about ¼ mi. from the storage basin, in 1914, as noted in *Engineering News*, May 31, 1914.

Tests were made of the inflow to the conduit by weirs placed on the supply main above the intake and on the waste below the intake. Simultaneous tests of the discharge were made by pitometer at a point 230 ft. upstream from the booster pumping station, which in turn is located 1,500 ft. from the distribution reservoir. Tests were made of the flow through the conduit under two conditions—with the booster pump operating and with the pump stopped (and bypassed), respectively. Each test was duplicated on the day following the original test, and in addition the results were checked closely by simultaneous pitometer records of the inflow to and outflow from the distribution reservoir in conjunction with the record of the gain or loss of storage in the reservoir. In order to permit coefficients to be determined for various friction-head formulas, the net results have been tabulated as shown in the following statement:

Pump in Operation:
Net friction head in the conduits, 134 ft.
Conduit in test, 13,000 ft. of parallel 12-in. and 10-in. pipe, plus 21,000 ft. of 10-in. pipe.
Mean discharge in gallons per 24 hr.—
By weir 1,410,000
By pitometer* 1,416,000
Pump Shut Down:
Net friction head in conduits, 110 ft.
Pipe involved, 13,000 ft. of parallel 12- and 10-in. pipe, plus 22,500 ft. of 10-in. pipe.
Measured discharge, 1,220,000 gal. per 24 hr.
*In determining the discharge by pitometer a traverse coefficient 0.83 was used.

For the same heads the Hazen-Williams formula, using $C = 130$, which is applicable to good new mains, fairly straight and well laid, gives for the same conditions, under 134 ft. head, a discharge of 1,410,000 gal.; and under 110 ft. head, a discharge of 1,218,000 gal.

There was a small but unknown draft from the supply conduit during the tests through services supplying kitchen sinks in dwellings along the line of the conduit. The rate of draft probably did not exceed 5,000 gal. per 24 hr. Blowoffs and air valves were opened preceding the test, and very little sediment was discharged.

A section of the pipe cut out at the booster pumping station showed its interior condition to be perfect. The coating was smooth and unbroken, without any sign of rust or tuberculation. The water is very cold, exceptionally pure and soft, coming from springs in sand hills.

The tests were made under the direction of Robert E. Horton, Consulting Hydraulic Engineer, of Albany, N. Y., and the pitometer measurements were made by A. W. Hogeland, of the Pitometer Co., New York City.

Vitrified Pipe as Well Casing

A kind of well that is giving satisfaction in the towns of Medway and Barnstable, Mass., is one having a casing of 24-in. vitrified sewer pipe. Wells of this type have been used in fine sand where small-sized iron-pipe wells with strainers proved unsatisfactory, because of clogging up.

The method of sinking the vitrified-pipe wells varied somewhat with the material encountered. A water jet was used in some instances, but a small orange-peel bucket excavator proved best in the majority of cases. The bucket was operated from a four-leg pipe derrick. The material in the bottom of the well was first loosened with a long bar. The wells described were about 30 ft. deep.

The bells of the pipe were cut off, as they would, of course, have interfered with the sinking. The sections of pipe were spliced together by three bars equally spaced around the outside circumference and parallel to the axis of the pipe. Holes were bored in the pipe, and the splice bars were fastened on by small carriage bolts. This was found necessary in order to keep the pipe in alignment, even with pipe having chamber-and-tenon joints.

WELL CLOGGING CURED BY USE OF VITRIFIED PIPE FOR WELL LINING

When it was necessary to make the upper joints watertight they were calked from the inside with oakum and cement mortar. The wells receive practically all the inflow through the open bottom. Should they fill up with sand or silt, they can readily be reëxcavated.

The completed wells have reinforced-concrete covers, which are locked on by running a rod through the pipe and through a staple on the under side of the cover. The rod is fastened on the outside with a padlock.

The wells were devised by H. A. Symonds and L. L. Wadsworth, engineers of the Hanscom Construction Co., Boston, Mass., for the water-works of Medway and Barnstable. The maximum depth to which such wells have been sunk is 35 ft., and the cost is about $200 each.

Grade Checks at Railroad Street Crossings

In an effort to reduce the number of accidents at grade crossings, the Board of Public Utilities, Los Angeles, Calif., is experimenting with grade checks or "bumps," especially constructed in the pavements to necessitate the reduction of speed of automobiles and other vehicles before crossing the tracks.

The experiment is being made at probably the most dangerous grade crossing in the city—the intersection at an oblique angle of the 4-track system of the Pacific Electric Ry. and Mission Road, a main route of travel between Los Angeles and Pasadena. Substantial grade checks are being constructed for a distance of about 50 ft. on each side of the tracks, so arranged as to demand careful driving and to eliminate any possibility of the dashing ahead of oncoming cars.

Prior to making this installation, speed data were taken at this point, and further investigations will be made after the completion of the grade check to determine accurately the value of this plan of crossing protection. Other plans suggested to the Board for inexpensive experiments include the construction of a large dip in the road, as well as the installation of sand beds for a suitable distance to compel a reduction of speed.

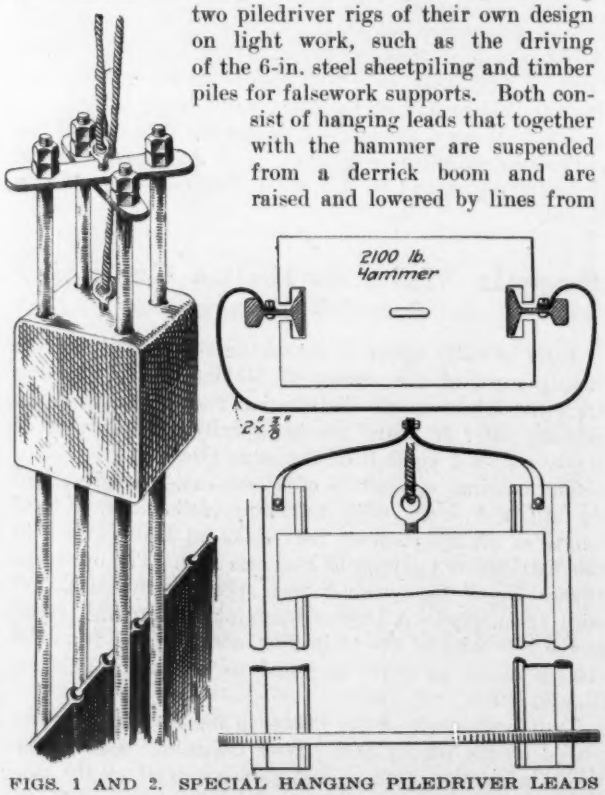
The principal parkway of the park system at Memphis, Tenn., has a length of about 12 mi. and has five railway grade crossings, some of the lines crossing diagonally. The Park Commissioners have installed ridges or "bumpers" across the roadway. These are placed also at a dangerous point where a county road enters the parkway on a steep grade, and at a point where a street-car line is crossed at the foot of 5% grades.

The bumpers are rounded ridges 9 to 12 in. high above the surface of the roadway, and are approximately 4 to 6 ft. wide at the base and 2 ft. at the crown. Where there is a double roadway only the right-hand roadway is thus marked. They are placed 50 to 75 ft. from the crossing or danger point, with "Go Slow" signs on the right side of the roadway about 100 ft. in advance of the bumper.

It is stated that crossing accidents have been noticeably absent since the installation of the bumpers, but that the "Go Slow" signs should be properly illuminated at night to secure the best results. J. E. Weatherford is city engineer of Memphis.

Two Light Piledriving Rigs

In the construction of the new concrete bridge across Lake Quinsigamond at Worcester, Mass., the contractors, C. W. Blakeslee & Son, of New Haven, Conn., are using two piledriver rigs of their own design on light work, such as the driving of the 6-in. steel sheetpiling and timber piles for falsework supports. Both consist of hanging leads that together with the hammer are suspended from a derrick boom and are raised and lowered by lines from



FIGS. 1 AND 2. SPECIAL HANGING PILEDRIVER LEADS

Fig. 1—(Left) Rig in which leads pass through hammer. Fig. 2—(Right) Light rails form hanging leads

the derrick hoist, the hammer directly from the drum and the leads from the snubbing spools.

Fig. 1 shows the lighter hammer of the two, which has a weight of about 1,400 lb. It is a special casting, provided with four longitudinal holes about 2½ in. in diameter. These holes serve as guides for four 2-in. rods that are the piledriver leads. The rods, joined together at their tops by the crossed plates shown, are hung from the derrick lines so as to fork over the pile being driven. They are quite rigid and effectively hold the hammer in line during the driving. In driving a single pile the bottom of the rods can be bound round with a line to position the leads, but in driving a line of sheetpiles this is not necessary.

The heavier rig, shown in Fig. 2, has a 2,100-lb. hammer of regulation design, but instead of the usual clumsy wooden leads, two 30-lb. rails are used. These are bound together at the bottom by a strap bent to clear the hammer and are held at the top by another strap, which also serves for the hanger.

Special Piledriver with Adjustable Leads

Demands for more space at the Gold St. generating station of the Edison Electric Illuminating Co. of Brooklyn, N. Y., made it necessary to increase the height of a one-story building there to four stories. In view of the greatly increased loading—total of 600 lb. per sq.ft.—it was decided that the foundations would have to be carried to hardpan. This was accomplished by driving a number of hollow steel piles, closed at the lower end by a projectile point, and placing foundation piers on top of the piles. The piles were driven into the soil—which consisted of fill, boulders and cribwork—a distance of 22 to 27 ft.

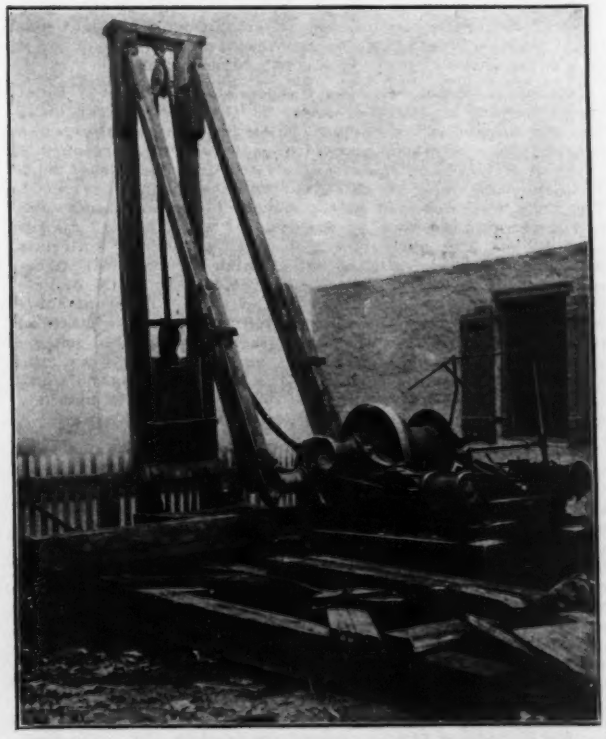


FIG. 1. SPECIAL PILEDRIVERS SET UP FOR STRAIGHT WORK; BROOKLYN, N. Y.

The piledriver used was especially designed for the job, the leads and braces being arranged so that the leads could be used as with the ordinary type of driver, as shown in Fig. 1, or could be dropped in the hole. The braces were hinged top and bottom and so adjustable that when the leads were in the hole the long upper member of the spliced braces could be removed and a shorter one substituted, as indicated in Fig. 2. With this arrangement it was not necessary to use a follower. These leads could be placed in many awkward positions which otherwise would have rendered necessary the use of sliding leads and special rigging. The work was done by John H. Duncan, contractor, under the supervision of G. L. Knight, Designing Engineer of the Edison Co. and Bernt Berger, Consulting Engineer. A year ago another foundation at this station was constructed by driving hollow steel piles not fitted with a point, and then excavating inside them by 10-in. orangepeel.

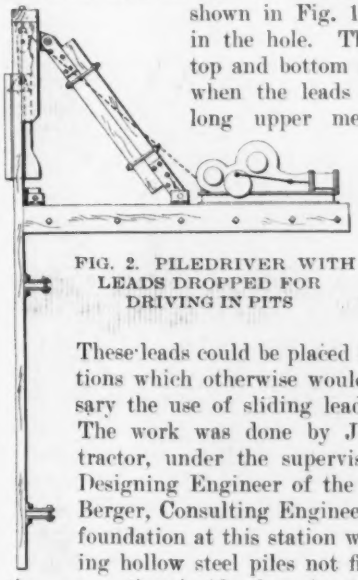


FIG. 2. PILEDRIVER WITH LEADS DROPPED FOR DRIVING IN PITS

Computing Paving Outside Curved Curbing

By Richard A. Lewis*

In the computation of the area of street surfaces where the corners of intersecting streets are rounded by a curb of some definite radius, the work can be made easier by the use of tables giving the area between the intersecting curb lines. Fig. 1 shows such an intersection and the area to be computed.

Areas of streets *A* and *B* are found directly from the product of their length by their width. Ordinarily the areas of *C* and *D* are found by taking one-fourth of the difference between the area of a circle of the given radius and the area of a square with sides equal to twice the radius of the circle. If the streets do not intersect at right angles, the computation is more complicated.

Table 1 gives the areas of *C* and *D* in square feet, where the intersection is at right angles, for any radius from 4 to 20 ft. for each inch change in length of radius.

Where the streets intersect at an angle of less than 90°, the areas of *C'* and *D'* are not equal, and each has a certain relation to *C* and *D*, depending on the angle of intersection. The ratio of *D'* in Fig. 2 to *D* in Fig. 1, for

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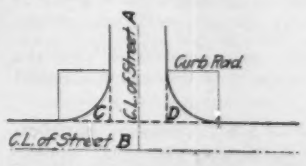


FIG. 1

FIG. 2

AREAS OF CURVED STREET CORNERS COMPUTED BY R. A. LEWIS' TABLES

the same radius, is a constant and is equal to the same ratio for any other radius. C' being subtended by the angle $180° - \phi$, has a different ratio.

Table 2 contains these ratios for every degree from 30° to 150°. Therefore, to obtain C', find the product of C in Table 1 and the factor for the angle which subtends C', in Table 2.

Example 1—Two streets intersect at right angles, with curbs rounded by a radius of 10 ft. The gutter of concrete is 20 in. wide. Here the brick or other pavement will not be estimated with the concrete gutter; hence the radius to use will be 11 ft. 8 in. From Table 1 the area for one corner is 29 sq.ft.

Example 2—Take the same conditions as in the foregoing, except that the streets intersect at 37°. As in Example 1, find 29 sq.ft. from Table 1. From Table 2, for 37°, find a factor 0.055 for D'. The factor for 143° (180° — 37° = 143°) will be found to be 8.112 for C'. Then 29 × 0.055 = 1.6 sq.ft. for D'; 29 × 8.112 = 235.2 sq.ft. for C'; 1.6 + 235.2 = 236.8 sq.ft. for the two corners.

TABLE 1. AREA OF PAVING OUTSIDE CURB WHEN STREETS INTERSECT AT 90°

	Inches										
Feet	0	1	2	3	4	5	6	7	8	9	10	11
4	3	4	4	4	4	4	4	5	5	5	5	5
5	5	6	6	6	6	6	6	7	7	7	7	8
6	8	8	8	8	9	9	9	9	10	10	10	10
7	11	11	11	11	12	12	12	12	13	13	13	13
8	14	14	14	15	15	15	16	16	16	16	17	17
9	17	18	18	18	19	19	19	20	20	20	21	21
10	21	22	22	23	23	23	23	24	24	25	25	26
11	26	26	27	27	28	28	28	29	29	30	30	30
12	31	31	32	32	33	33	34	34	34	35	35	36
13	36	37	37	38	38	39	39	40	40	41	41	42
14	42	43	43	44	44	45	45	46	46	47	47	48
15	48	49	49	50	50	51	52	52	53	53	54	54
16	55	56	56	57	57	58	58	59	60	60	61	61
17	62	63	63	64	64	65	66	66	67	68	68	69
18	70	70	71	71	72	73	73	74	75	75	76	77
19	77	78	79	80	80	81	82	82	83	84	84	85
20	86	87	87	88	89	89	90	91	92	92	93	94

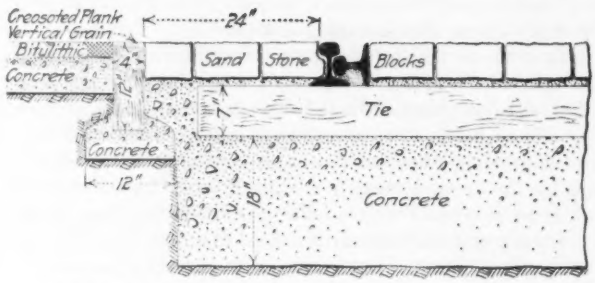
TABLE 2. RATIO OF CONDITIONS WHEN STREETS INTERSECT AT LESS THAN 90° TO THE CONDITIONS AT A 90° CORNER

Deg.	0	1	2	3	4	5	6	7	8	9
30	0.029	0.032	0.035	0.038	0.042	0.046	0.050	0.055	0.059	0.064
40	0.069	0.075	0.081	0.087	0.093	0.100	0 107	0.115	0.123	0.131
50	0.140	0.149	0.158	0.168	0.178	0.189	0.201	0.212	0.224	0.237
60	0.250	0 264	0.279	0.294	0.309	0.325	0.342	0.360	0.378	0.397
70	0.416	0.437	0.458	0.480	0.502	0.526	0.550	0.575	0.602	0.629
80	0.657	0.686	0.716	0.748	0.780	0.813	0 848	0.884	0.922	0.960
90	1.000	1.041	1.084	1.129	1.175	1.223	1.272	1.323	1.375	1.430
100	1.487	1 546	1.607	1.670	1.735	1.803	1.873	1.946	2.022	2.100
110	2.182	2.266	2.354	2 445	2.540	2.638	2.740	2.846	2.957	3.072
120	3.191	3.316	3.446	3.581	3.722	3.869	4 022	4.182	4.349	4.524
130	4.707	4.898	5.099	5.309	5.529	5.760	6.003	6.259	6.527	6.811
140	7.110	7 426	7.759	8.112	8.486	8.883	9.305	9.754	10.233	10.744
150	11 291	11.879	12.509	13.188	13.922	14.717	15.579	16.520	17.548	18.677

NOTES

Paraffin-Wax Coating for Filter Tanks and Pipes—The wetted interior of the steel filter tanks and the inside of the pump and filter piping of the new drifting-sand water-filtration plant now being built for the City of Toronto by the John ver Mehr Engineering Co. are coated with solid paraffin wax, dissolved in gasoline at a minimum temperature of 110° F. Before coating, the surface is cleaned with wire brushes. This cleaning must be thorough, and the surface must be dry before the paraffin is applied. The coating is put on with whitewash brushes. Paraffin wax was chosen because it was feared that the common tar or asphalt coatings would break away in sufficient quantities to clog the sand-collecting and removing system that takes drifting sand from the filters.

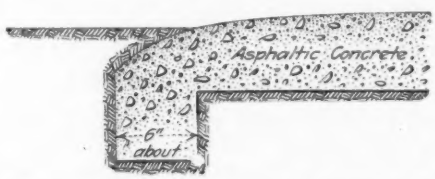
A Railway Street Crossing that has proved very satisfactory at Pueblo, Colo., is shown in the accompanying illustration. This method was first tried on the Atchison, Topeka & Santa Fe Ry. crossing on the recommendation of the railway's engineers. The header blocks are 12-in. lengths of 4x12-in. creosoted plank on end. The great advantage claimed for this type of crossing is that it entirely separates the pavement



RAILWAY CROSSING FOR PAVED STREETS IN PUEBLO, COLO.

from the railway-track area, so that reconstruction of the track will not require any disturbance of the pavement. D. P. Gaymon is city engineer.

An Edging for Asphaltic Pavements which has given good service in some Southwestern cities is shown in the accompanying illustration. It is used in place of a header where the pavement joins an unpaved street as well as at the ends of a section of paving. So far as known it has never been tried



AN EDGING FOR ASPHALTIC PAVEMENTS

as an edging for asphaltic road pavements, but it would seem to be a feasible solution of that vexing problem. The beveled end with a thin cushion of soil saves the edge of the pavement from abrasion and the small amount of additional material under the edge avoids the feather-edge ends or sides of a pavement, which are constantly breaking off.

Cleaning Outfall Sewer of Quicksand—About 10,000 ft. of 21-in. vitrified pipe outfall sewer at Great Bend, Kan., was recently cleared of quicksand, which had entered through a broken pipe. In some places the quicksand had reached a depth of 15 to 18 in. The cleaning out was accomplished with 15-in. wooden balls weighted so that they would just float. The balls were inserted in the sewer at manholes and were forced through the pipe by the head of water backed up behind them. The quicksand and other suspended materials were cut out underneath the balls, which revolved in a direction opposite to the current. At times 6 to 10 cu.yd. of material was being moved ahead of the balls. The contractor who was in charge of the work stated that the more material in front of the balls, the more satisfactorily the scheme worked. Cleaning was begun at the manhole nearest the outfall; the balls were then placed in the second manhole and taken out at the first, and so on. About every fifth manhole a ball was allowed to go through to the end of the sewer.

Distribution of the Load and Moment to the beams supporting an oblong rectangular concrete slab reinforced in two directions is not standardized. M. G. Findley, 59 W. 57th St., New York City, inquires as to prevailing practice. He notes that there is authority for three methods of distribution, as follows: One, triangular, that is assuming a triangular load on each beam, the maximum ordinate being at the middle of the beam and the proportion of the total load borne by each beam varying as the ratio of the fourth power of the length of that side of the rectangle to the sum of the fourth powers of the two sides; two, parabolic, in which the load varies as the ordinates of a parabola; three, equiangular, that is where the distribution to the short beam is that part of the load included in the triangle made by bisecting the corner angles. He also inquires whether there is any authority for a uniform distribution of the load to the beam, that is the use of WL ÷ 8 instead of the WL ÷ 6 imposed by the triangular method, particularly in the design of steel beams supporting concrete slabs reinforced in two directions.

An Aëroplane as an Engineering Tool was recently used by a California engineer. The problem had to do with city planning and beautification and photographs taken from the flying machine at a great height served to visualize the city layout so that the effect of the new design could be realized.

Editorials

Raising Railway Trainmen's Wages by Act of Congress

The nation-wide railway strike ordered by the trainmen's brotherhoods for Sept. 4 was called off because 36 hours before the time fixed, Congress, under the whip and spur of President Wilson, passed a law compelling the railways to grant to the trainmen their principal demand. This demand, while it is called the eight-hour day and so masquerades in the law passed by Congress, is, when stripped of technicalities, merely an increase of 25% in the hourly wage rate to all railway train service employees engaged in interstate commerce.

Congress dropped all its other work and postponed its day of adjournment in order to enact this law under the same compelling motives that influenced President Wilson when he attempted to make the railway executives grant the demands of the brotherhoods. He believed that a nation-wide railway strike must be averted at any cost and hence that the demands of the brotherhoods must be granted, without stopping to inquire whether or not they were justified.

This remarkable piece of Congressional legislation which was rushed through the Senate while the Brotherhood leaders sat in one of the committee rooms and issued orders as to the form the legislation should take and the limit of time in which it must be passed, had the desired effect of postponing the strike. The issues that are raised by the legislature, and which must be passed upon at an early day, Congress has turned its back upon for the present.

It was long ago said that nothing is ever settled until it is settled right. If the President and the Congressmen at Washington imagine that they have made a permanent settlement of the railway-wage question by this legislation, they are sure to find their error and find it very quickly. Let us suppose that in accordance with the President's desires the railway companies accept and carry into effect the provisions of the law. Some very important questions are nevertheless bound to be raised.

Has Congress the power, under the interstate-commerce clause of the Constitution, to order a wage increase to a certain class of railway employees? It has power to enact minimum-wage laws and hours of service laws, unquestionably; but to pass a law that railway corporations shall raise the wages of their employees is a very different matter.

Suppose, however, it is decided by the courts that Congress has this power. In that case, next winter, we shall see Congress legislating on the wages and hours of labor of the railway shopmen, switchmen, station agents, signalmen, sectionmen, bridge gangs and each and every other class of labor employed by railway companies. The humble officials may even come in for a favorable bill or two, for some of them are drawing fewer dollars from the monthly pay car than the engine runners for whose benefit the Congressmen put off adjournment and worked overtime—and without extra compensation either!

Why should there be objection to such legislation? Each and every class of railway employees is probably better entitled to a raise than the trainmen. Shall these others be denied it merely because they have not threatened to tie up the entire commerce of the nation?

But the avalanche will not stop there. If Congress may enact such legislation, then state legislatures may pass laws raising wages of employees of all public-utility corporations within their jurisdiction. Next winter, then, will see bills passed at Albany and Harrisburg and Sacramento and every other state capitol to raise wages of street-railway motormen, conductors, linemen and a hundred other classes of workmen in the employ of public-utility companies. That is a far easier way to get a raise of wages than striking. Will the street-car men and all other employees of public-utility companies be deep in state politics from this time on? Nothing is more certain.

Perhaps it is well to turn back to the question: Has Congress the power under the Constitution to pass such a law as it rushed upon the statute book? It has not that power if and where the effect of such a law will be to reduce the net earnings of a railway below a fair return on the legitimate investment, for that would be "taking private property without just compensation." Only that brief clause of the Constitution stands in the way of confiscation of the railways and all other public utilities of the country; but that still stands.

A nation-wide railroad strike would be a vast calamity; but there might be a worse calamity. To forsake the principles of right and justice; to yield to the threat of a vast labor monopoly, for fear of immediate consequences, without foresight of other consequences to follow—that may be far worse in the long run for the nation.

A century ago an American statesman won undying fame by declaring that the United States had millions for defense, but not one cent for tribute. One longs to see a little of that spirit among those in authority at Washington today.

What Water Meters Will Do

When an American city has a water consumption of only 35 gal. per capita, it is safe to assume that practically all the water passes through meters. Woonsocket, R. I., shows a consumption of 34.5 gal. per inhabitant and 34.7 per consumer. Of the 3,928 services, 3,837 or 97.9% were metered at the end of the year 1915, and of the total consumption, 83.2% passed meters. Of the water pumped, 84.2% could be accounted for without allowing for meter slip.

Such a record is one for the Water Department and Superintendent Carleton Scott to be proud of, and for meter advocates, including the manufacturers, to make the most of.

It should be noted, however, that some factors for which the Woonsocket Water Department can claim no credit nor be given any blame favor low consumption.

The mileage of mains is low compared with many cities of equal population, the service connections are short and notwithstanding the low per capita consumption each service or tap passed 456 gal. per day. All these things indicate a compact distribution system, with fewer main and service joints than are common to cities of 45,000 population.

The Water Department did not depend on meters alone. During the year, Mr. Scott says, "The customary assistance has been rendered consumers in our efforts to prevent the waste of water, and 707 postal card notices have been mailed."

After all is said by way of explanation, it is the universal meter system at Woonsocket that accounts for the low water consumption and waste in that city—that is, meters and generally efficient management. Other cities with a like combination can get equally good results.

Educate the Water Boards

Every superintendent of a municipal water-works, we venture to assert, is or has been at some time handicapped by his inability to get the local water board to back up his recommendations for work which he knew was necessary for the service. If the average standard of members of water boards could be improved in the same degree that the standard of water-works managers and superintendents has been in the last two decades, the quality of water-works service would be materially raised the country over and the cost appreciably reduced. The trouble is evident, and it lies in ignorance and inefficiency rather than in dishonesty. Some means should be sought to educate the water-board members or to select better men.

A few illustrations come conveniently to hand as to the urgent need of a better understanding of their responsibilities by village trustees, members of water boards and other public bodies to whose tender mercies are committed the control of the water-works systems of our smaller cities and towns.

The first case involves the very important matter of water waste. Much has been written on waste prevention; waste detection has become almost an exact science. Yet, withal, extravagant use of water is rampant and restriction is a difficult and delicate task, even when the facts as to the existence and sources of waste are well known. Water-works engineers understand the difference between waste detection and waste prevention, but water boards and village trustees generally do not. Once a leakage survey has been made the board seems to expect the wastes to stop forthwith of their own volition.

In a certain town in the East, the distribution reservoir supplying a population of several thousand has been full but once in the past year—and several times it has been empty. Waste by consumers of all classes has grown until the consumption now exceeds the capacity of the supply line—although this is adequate with a reasonable consumption for 50% increase in population. The water-works superintendent has been subjected to suspicion and vilification because his plant could not deliver to the people all the water they wanted. Some members of the water board were inclined to credit these aspersions. The governing body fortunately employed expert service, and this dispelled the delusions and traced the shortage to the prodigal consumers. Those who most loudly denounced the superintendent were the largest wasters.

Even now the board experiences great difficulty in comprehending that its troubles have not ended and that the burden of remedying conditions rests on it. One of the trustees has just suggested that the board "lay a new main and let the people have all the water they want"—failing to realize that increased supply and unrestricted waste will only add temptation to further extravagance.

Another case: In an Eastern city the water consumption, although it was extravagant and the points of excessive draft were known, had been allowed to grow unrebuked until it had reached the capacity of the filtration works. Filtration was costly and æsthetically not entirely satisfactory. Something had to be done. A public meeting was called and the restriction of waste suggested. What happened? An old and influential member of the water board rose before the assembly and, with streaming tears and trembling voice testifying to his emotion, shouted, "I will not stand for a restriction; while I have been on this board the people have always had all the water they wanted." He spoke truly. Water they had, to use and to waste. Householders going away for Christmas week were known to leave all faucets wide open and closet trip levers tied down to prevent freezing. Filtered water and no meters!

The trouble with these two governing boards, so far as water waste goes, can be briefly stated: (1) Permitting a rampage of extravagant use until restriction was imperative; (2) shifting the burden of enforcing restriction upon the next generation in office.

We said that many water boards needed education, and the matter of water waste afforded a convenient illustration. But it is not the only one, for wisdom is sadly needed in other respects.

A good-sized city in the Middle West recently spent the price of a college education in teaching one of its board members a single simple fact. He was honest, conscientious and in many ways a most capable man, a plumber by trade. But he had great difficulty in understanding how it was that head could be lost by friction in a water conduit. His idea seemed to be that the capacity of a water-works conduit was some fixed and definite amount which it would deliver to the outlet at the same level as the intake, arguing apparently that water seeks its own level and the more it seeks the faster it runs. This man overrode the superintendent and imposed a construction in accordance with this novel principle.

In small towns the superintendent is often the village plumber, the whole responsibility for policy and administration resting on the trustees. What is to be said about one such town which, needing at least an 8-in. main from its intake to its distribution reservoir, replaced a defective 6-in. main several miles long by a 4-in. pipe, the trustees intending as they said to put in another 4-in. pipe later on "when they needed it" and arguing that "two fours would be better than a six anyway."

The circumstances noted are all well authenticated and all less than five years old. They are typical and not exceptional. They indicate that no matter how capable, experienced and qualified the superintendent or engineer may be, his utility to the public is limited by the mental equipment of the board under whose control he must act. How can better boards be secured? How can the old boards be educated? Close the doors of the next water-works convention and discuss this momentous question.

Try State Ownership of Railways on the Boston & Maine

There is without question a very large amount of public sentiment in the United States which favors government ownership of railways, and there has been a steady growth in this sentiment during the past twenty years. There is no doubt either that the events of the past decade have been forcing the United States toward government railway ownership at a rapid rate. All the details of railway operation, including the rates that may be charged, are now subject to regulation and control by state and Federal authorities. Not only this, but the events of the current week have rendered practically certain that the rate of wages will likewise be subject to public regulation.

Under these conditions, unquestionably, a large part of the arguments in favor of continuing the system of private railway management no longer holds good. If railway superintendents and managers have to be mere clerks to carry out the policies that public bodies dictate, the public might as well take over the title to the railways, so that it and not the private owners of railway securities will suffer or will profit from the policies its representatives may put in force.

There is a very large body of intelligent public opinion, however, including those who are most familiar with the science of transportation, who believe that the United States is in no condition as yet to assume government ownership of its railways. One may point to the contrast between the efficiency of American railway operation and the inefficiency and wastefulness with which government work, both state and Federal, is carried on in the United States.

These arguments have been many times set forth and are familiar to most intelligent men. We do not propose to rehearse them now. Instead, *Engineering News* makes the suggestion that before the United States finds itself forced to adopt the policy of government ownership, it should experiment with that policy, not on all the railways of the country, but on one railway system of fair size, located where the operating results may be publicly known.

If that experiment demonstrates the weaknesses of government ownership, it will have more influence with that portion of the public which is now ardently advocating government ownership than all the other arguments that could be presented.

It is true, of course, that government ownership of railways has actually been tried and abandoned in the United States. A number of the states of the Union and some cities tried the experiment of building and owning railways in the early days of the railway era and found the results unprofitable. But while these matters of history are well known to the railway expert, they are unknown and would be unconvincing to the general public. The public will not be convinced, either, by arguments as to the inefficiency with which railroads are operated when they are in the hands of the United States courts. The disastrous results of government ownership in Canada likewise fall on deaf ears.

If, however, an important railway system in the United States were to be transferred to government ownership and operated for a number of years, convincing proof would be available as to whether the railway earned more profits, gave better service, kept its employees satisfied without strikes and in general attained the success that the advocates of Government ownership claim as compared with the results obtained under previous private ownership.

There is an excellent opportunity now to try government ownership on the Boston & Maine system in New England. That system has just been placed in a receiver's hands. There has been for years general public dissatisfaction with the Boston & Maine management, both on the part of the public that the road serves and the owners of the road's securities. The railways composing the system are among the earliest built in the United States, and they transverse an old settled portion of the country where traffic conditions are stable and the scale of public intelligence is high. In no section of the United States, probably, could public ownership be tried under more favorable auspices or with greater certainty that the results will be carefully watched so that either failure or success will become widely known.

Of course, if the experiment of public ownership were tried on the Boston & Maine, it would have to be tried by the several states through which the system runs and not by the Federal Government. These states, however, are as well able to undertake it as any states in the Union. New England has never done its fair share anyway in the line of experimental work in popular government and the states of the Pacific Coast have done more than their share. It is time that New England contributed to our general experimental knowledge of the science of government by trying the state ownership of railways.

Ingenious Water-Supply

The old proverb, "Where there's a will there's a way," applies admirably to a great deal of the engineer's practice. But to develop a water-supply for a section of the country where there is not any water to be had requires something more than will power. Such conditions are met with in parts of the arid West.

Ever since the Santa Fé Ry. was built across Arizona, on the high plateau above the Grand Cañon of the Colorado the water-supply of the railway (and the towns it has given birth to) has been a source of trouble and expense. There are several points along the line, notably Seligman, Williams, Flagstaff and the Santa Fé hotel El Tovar and the surrounding settlement on the rim of the Grand Cañon, where water has to be brought long distances by rail in tank-cars and then dispensed by the gallon with about as much circumspection as gasoline.

Water at the El Tovar is so precious that very little of it is wasted. The sewage is treated at a disposal works, and the effluent is used to sprinkle lawns and in the boilers of the pumping and power plant. Two qualities of water are supplied there, the potable water being hauled all the way from Del Rio about 70 mi. away.

Under such conditions the development of a pure water-supply of about 2,000,000,000 gal. annually, at a cost of about a quarter of a million dollars, is an engineering feat of considerable ingenuity, especially so when it is accomplished under the very noses of the railway water-supply engineers who have been working on the same problem for many years. This and some of the out-of-the-ordinary details describing the work on San Francisco Mountain lend interest to the brief article elsewhere in this issue.

Letters to the Editor

Jamaica Uses "Sausages" for River Protection

Sir—With reference to the article on p. 79 of your issue for July 13th on "Rock-Filled Wire-Mesh Bags for River Protection" it may be of interest to you to know that this type of river protection has been in use in India for many years and that a full description of it is given in the *Proceedings* of the Institution of Civil Engineers Vol. CLXXIII, p. 244.

During the last six years such "sausages" have been extensively used by this Department for river training and bank protection and have in most instances proved effective and cheap. J. N. PARK,

Director of Public Works, Jamaica.

Kingston, Jamaica, Aug. 10, 1916.

Quebec Bridge Erection

Sir—In the article "Quebec Bridge in Picture" in your issue of August 24, you were good enough to make complimentary reference to the names of those connected with the work. The ease with which the work has gone together in the field and the rapidity of erection has been in large measure due to the practically perfect shop work, for which our Works Manager, W. P. Ladd, deserves the principal credit. I think his name should be added to your list. G. H. DUGGAN,

Chief Engineer, St. Lawrence Bridge Co.

Montreal, Aug. 26, 1916.

"Reforming Railway Curves"

Sir—To those of us who have been reading the *Engineering News* for lo these many years the persistence and ever recurring efforts of each successive wave of engineers to reform the railroad curve are either amusing as we realize the futility of it, or serious if we think of it as another sign of the lack of that coördination of commonsense with instruction in basic principles, which Professor Swain claims our methods of technical education fail to impart.

Those of us who are not so far away from the small end of a transit that we have forgotten the sweat dropping on our notebook on a hot summer day in Texas, or the cold breezes playing over our fingers when the thermometer was near the freezing point, while we figured P. T.'s and P. I.'s, will never thank anybody for suggesting anything but even degrees of curvature. And if Mr. Kitts or Mr. Palmer thinks that talking about a curve of 2,864.93-ft. radius conveys any clearer idea to anybody than does the reference to a 2° curve, or that any transitman wants to figure the deflection angle, etc., for a 3,000-ft. radius curve, I would suggest that they go out on the turf some hot summer's day when the heat waves make the back flag look like the reflection of a periscope on a gently rippling stream, and listen to the stream that flows from that transitman, as he tries to work out the odd seconds.

If this is not satisfactory, or does not convey the necessary atmosphere, more interest will be created by asking him to figure the exact length of chord to be measured to correspond to a 100-ft. arc or arcs of odd lengths, when the even station comes on a rock or in the middle of a 24-in. pin oak, and then listen to what the head chainman has to say when he measures 94.896 ft. and gets the tack in "right there."

A knowledge of polar and rectangular coördinates may be a fine equipment for the mathematician, but for running in or calculating railroad curves it is a particularly good part of the equipment on which to accumulate a delightfully warm colored coat of rust.

I am afraid that there are too many mossbacks in the railroad end of the game to hold out much hope of conversion, even where, as in this case, the theory is fine, but the practice better. F. LAVIS.

New York City, Aug. 18, 1916.

Why Put a Gravel Cover on the Concrete Floor of a Bridge?

Sir—In *Engineering News* of Aug. 17, I notice an extract from the *Minnesota Highway Journal* cautioning road supervisors to be careful and not place too thick a gravel cover on the concrete slab floors of steel truss bridges. The article says:

> It is very important that this covering be thick enough to protect the slab from the horses' calks and from the mud hooks on traction engine wheels, but it is also important to prevent making it so thick that the bridge will be overloaded.

The article then goes on to give details of placing the gravel covering and states that on truss bridges the gravel should be only 2 in. thick at the sides and 4 in. thick at the center, but that it is not uncommon to find truss bridges with gravel of an average thickness of 9 in. on top of the concrete floor.

Any one familiar with the lack of attention from which the average country highway bridge suffers can readily understand how any such bridge may be at any time dangerously overloaded with gravel notwithstanding all the circulars that a state highway commission may put forth.

The question arises, however, what is the sense of placing gravel on the bridge at all? Why not make the concrete floor slab thick enough in the first place to stand the wear and let the traffic run directly on it? Experience has now demonstrated that the rate of wear of concrete roads, even when subjected to heavy traffic, is exceedingly small. With the traffic of the ordinary country highway, the concrete floor slab, assuming of course that it were made of proper concrete, would last for a generation before its strength became impaired. If any surfacing whatever is to be put on the concrete floor of a country highway bridge it should be a coating of asphalt composition, either a thin carpet coat such as is used on

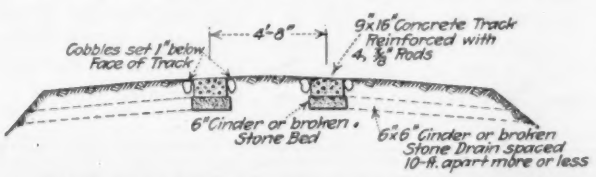
the California concrete state highways, about ⅜ in. thick, or, if the traffic is sufficient to demand it, a regular asphaltum wearing surface 1½ in. thick. Facilities for doing a good job in applying such an asphalt top coating, however, are so seldom available in country highway bridge construction that the best plan, almost invariably, will be to make the concrete thick enough for the traffic to run directly on it. This will make a much more satisfactory floor surface than any gravel covering, for gravel on a concrete floor dries out so quickly that it is bound to ravel under traffic. C. E. V.

Syracuse, N. Y., Aug. 25, 1916.

Concrete Tracks Proposed for an Earth Road

Sir—Have any of your readers ever seen tried the improvement of an earth country road with two concrete tracks, as shown in the accompanying sketch?

It would seem that on a road of light traffic, where vehicles pass not oftener than once per mile, such a type of road would meet the special requirements. Water-


Cobbles set 1" below Face of Track
4'-8"
9"x16" Concrete Track Reinforced with 4, ⅜" Rods
6" Cinder or broken Stone Bed
6"x6" Cinder or broken Stone Drain spaced 10-ft. apart more or less

PROPOSED CONCRETE TRACKS ON EARTH ROAD

bound macadam roads wear in ruts, and a new road is generally required every three or four years because 50% of the surface has worn out. The more expensive bituminous pavements are too costly, and what actually happens is that a waterbound macadam is laid and is made to answer its purpose long after it has worn out. When, after a bad winter, the road becomes impassable, another waterbound macadam road is built and another cycle is begun. FREDERICK T. WARNER.

39 Pangborn Place, Hackensack, N. J., Aug. 3, 1916.

[The scheme described above is not new, but has been several times proposed. A few weeks ago the newspapers reported a Texas inventor as endeavoring to raise capital to build a large mileage of toll roads on the general scheme presented above. We are unaware whether the scheme has been actually tried in practice anywhere. The late Gen. Roy Stone, the first chief of the Federal Bureau of Road Inquiry, extensively exploited the idea of paved wheelways for vehicles. He finally succeeded in having an experimental line of rails with broad surfaces for wheels laid down on Murray St., New York City. These rails were found to be more of an injury than a benefit and were taken up after a few months.

It does not seem probable that such narrow concrete tracks as are shown in the sketch, laid in an ordinary dirt road, would give satisfaction. In certain seasons of the year, Jersey mud is very deep and very slippery, and an automobile which turned off the concrete strips to pass another car would be apt to have a good deal of difficulty in getting back onto them. To make the scheme practicable, the space between the concrete tracks and a certain width on each side of them would have to be paved with gravel or macadam. It would be very difficult to make a good job of placing and compacting the gravel or macadam after the concrete tracks were built. Further than this, when the whole job was done it probably would be less satisfactory to traffic and less durable in service than a narrow, single-track, concrete road. In the section shown in the sketch there is enough concrete to make a concrete road 6 in. thick and 4 ft. wide. With the added cost of foundations, shoulders, surface treatment, additional forms, etc., it is probable that a concrete strip 7 ft. in width could be laid at no greater cost than the two-rail concrete road shown in the sketch. While a 7-ft. concrete road is narrower than is advisable for single-track service, it is practicable to move traffic over it; and there can hardly be a question that it would be a much more durable and satisfactory road than the one proposed.—Editor.]

Baltimore Imhoff Tank Foams

Sir—The inclosed photograph of the gas vent of one of the Imhoff tanks at the Baltimore sewage disposal works shows one of the difficulties which are encountered in the operation of Imhoff tanks, namely, "foaming." On two recent occasions, when I visited the Baltimore plant, the vents were "foaming," both of the visits being in the summer time. The accompanying picture was taken on July 19.

The remarkable thing about this "foaming" lies in the fact that the vent is nearly 5 ft. high and the gas

FOAMING AT GAS VENT OF IMHOFF TANK, BALTIMORE, MD.

decomposition in the digestion chamber was sufficient to raise this foam the full 5 ft. and to cause it to spread over the surface of the settling tank as shown.

When one of these tanks "foams" the attendant immediately turns a fire stream on it for the purpose of breaking it up and cooling it off. The theory is probably the same as in the case of a tea kettle which boils over—if a little cold water is added it will stop the action.

CLYDE POTTS.

30 Church St., New York City, Aug. 18, 1916.

NOTES AND QUERIES

The Dragline Wagon Loader described on p. 78 of "Engineering News," July 13, 1916, stated that it was "devised" by the contractor owners, Barbeau & Werring, Minneapolis, Minn. The statement would have been more correct if "revised" had been used in place of "devised," for subsequent information proves that the wagon loader is one of the Albrecht excavators and loaders manufactured by the T. L. Smith Co., of Milwaukee, Wis., which the contractors changed to meet some local requirements.

Modern Sand and Gravel Plant Formally Opened

A large sand-and-gravel plant has been built at Marlborough, N. Y., a few miles above Newburgh, and its completion was signalized by a clambake given at the plant by the John B. Rose Co. on Aug. 30, more than 200 engineers, contractors and building-supply men being present.

The general arrangement of the plant is well shown in Fig. 1, where a 3½-yd. long-boom 175-B Bucyrus shovel digs from a bank 90 ft. high and piles the material convenient to a belt conveyor leading to a 7½-in. and 4½-in. gyratory crusher. Here the material falls on the main conveying belt and is lifted to a pair of scrubbers, falling thence into a series of sand separators, from which the gravel is conveyed by belt to a storage pile and the sand is either elevated to a sand-storage pile or if a barge be available is carried by belt on board, receiving on the way a final washing for gravel.

Shovels of the type shown are familiar enough in coal-stripping work but unusual in gravel pits. The 75-ft. boom and the height of the cab above ground permit the shovel to stand off a considerable distance from the bank, thus making it safer from possible cave-ins. Its capacity is given as 500 yd. per hr.

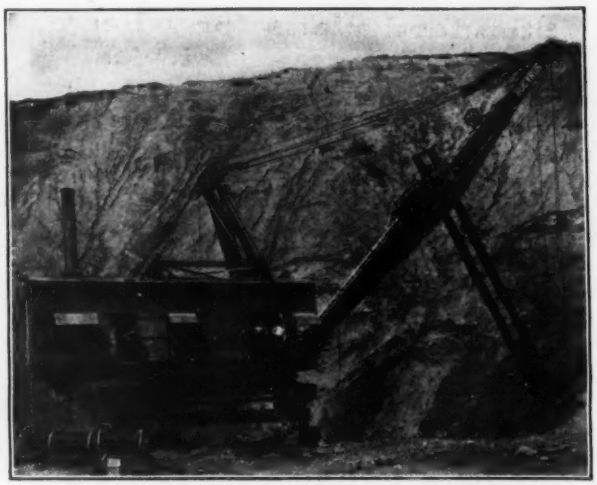


FIG. 2. BIG LONG-BOOM BUCYRUS IN 90-FT. BANK

The output at present is from 2,000 to 2,500 yd. of sand and gravel per day. The demand is so heavy at the present time that it is purposed shortly to put on a night shift when the total daily output will probably reach 4,000 yd. John B. Rose is president of the company and George C. Hudson is superintendent.

FIG. 1. VIEW OF NEW SAND AND GRAVEL PLANT OF THE JOHN B. ROSE CO., NEAR NEWBURGH, N. Y.

Standard Plans for I-Beam and Concrete Bridges

The use of standard highway bridge designs so that certain stock drawings can easily and readily be prepared to fit any crossing is a result of the growing importance of governmental highway departments. Several of such standard designs prepared by state highway officials have been noted in these pages. Herewith is shown a standard developed by R. L. Longshore, Assistant County Surveyor of Adams County, Indiana, and used on the county road system. The bridge consists of I-beam stringers incased in concrete, spanning between concrete wing-wall abutments and carrying a concrete-slab floor integral with the concrete casing. Standard drawings, such as the one shown in Fig. 1, are prepared; and every dimension line is marked on the tracing with a small black block that, showing white on the blueprint, leaves space in which to insert the proper dimension to fit the particular bridge. The design covers spans from 6 to 36 ft., using 6-in. 12¼-lb. beams for the former and 20-in. 85-lb. beams for the latter. Beams are spaced 3 ft. c. to c., requiring eight for a 20-ft. roadway and seven for a 16-ft. roadway. The beams rest on wall plates made up of steel channels embeded in the concrete at each abutment. The beam bearing is 12 in. for all spans below 18 ft. and 18 in. for all spans greater. The floor is a 6-in. slab with the bottom of the floor 2 in. below the tops of the beams. The beams are incased in concrete to prevent rust, but the concrete also takes the place of the transverse angles usually found in bridges of this type.

Parapet walls are 30 in. in height as a rule, this height having been found most satisfactory. For short spans and ordinary-height abutments plain concrete is used for the substructure. However, for the longer spans, high abutments or difficult foundations special reinforced substructures are specified.

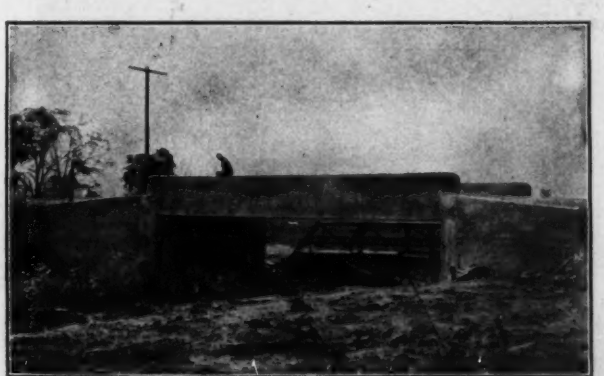


FIG. 2. TYPICAL STANDARD INCASED I-BEAM BRIDGE IN ADAMS COUNTY, INDIANA

The bridge shown in Fig. 2 was built during the season of 1916 by the Herman Tapp Construction Co., of Fort Wayne, Ind. The clear span is 36 ft. 6 in., with 18-ft. abutments and 20-ft. clear roadway. The floor is covered with 4 in. of limestone macadam as a wearing surface. Drainage is provided over the wings. Concrete is one part cement, two parts washed sand and three parts 1½-in. crushed stone throughout. The contract price for this structure was $3,100.

This type of bridge is particularly fitted for locations providing scant headroom. It may be built by semi-skilled labor under ordinary inspection. The use of I-beams allows a minimum of staging and forms; and by the use of standard reinforcing in the slab, misplaced reinforcing is almost impossible.

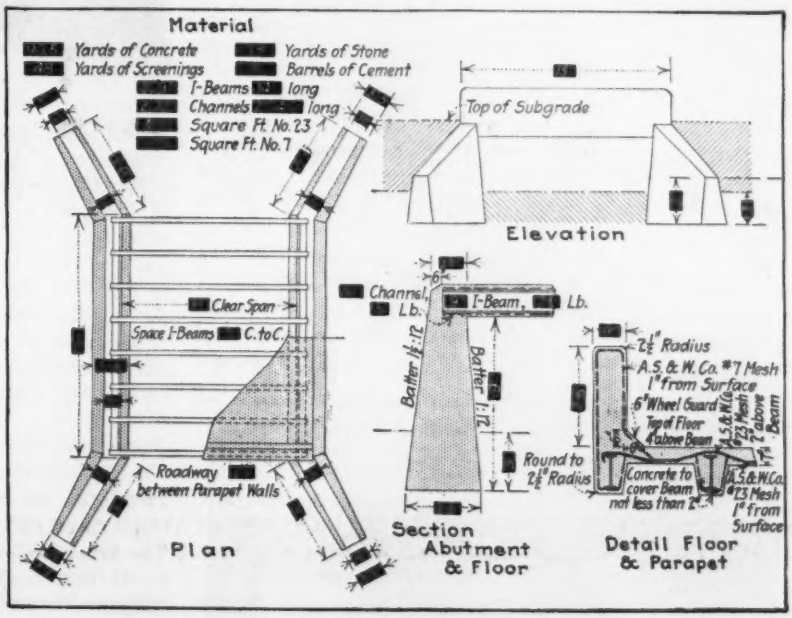


FIG. 1. STANDARD DRAWING FOR HIGHWAY BRIDGE USED BY ADAMS COUNTY, INDIANA

The various dimensions in the blocks on the dimension lines are filled in to suit each bridge

Computing the Cost of Good Roads—The first thing to be considered in buying good roads is the amount of money which it is wise for a community to spend for them. Find out roughly how much money can be devoted to road work, divide the assessed valuation of the district by the miles of Wayne County, Mich., on the other hand, has a valuation of only $5,420 per mile, showing that not even the entire wealth of the county is sufficient to improve all its roads. Wayne County, Mich., on the other hand, has a valuation of $514,931 per mile, indicating its financial ability to carry out any kind of road improvements in reason. There is a measure of the need for roads, just as there is a measure of the financial resources for roadbuilding. This measure is the travel the road is carrying now and the probable increase in the travel during the next five to ten years. The present travel can be actually counted, however, and this should be done. The State Highway Department or the United States Office of Public Roads and Rural Engineering at Washington will furnish instructions for the work. In determining the annual cost of a road, the first element is the first cost of construction per mile of road, including all engineering expenses. Knowing the travel over the road, an expert can estimate the number of years such a road will serve its purpose, if properly maintained, before reconstruction is necessary. This cost divided by the number of years of service gives the annual first cost. To this must be added the annual interest on the first cost per mile and the annual payment into a fund which will be enough to reconstruct a mile of the road when it is worn out, or to retire the bonds that are sometimes issued to pay for the first cost. The annual cost per mile of maintaining the road in serviceable condition is the last item. The sum is the total annual cost per mile.

Profit in Water-Works Forestry at Nashua, N. H.

Some very interesting experience in water-works forestry is that of the Pennichuck Water Co., Nashua, N. H., of which William F. Sullivan, President of the New England Water-Works Association, is Chief Engineer and General Manager. While forestry has become an important side line with many municipal water-works departments, in very few instances has it been possible to start experiments with watersheds already well forested, or in few instances have experiments progressed long enough to prove forestry on a 1,000-acre tract a profitable or even

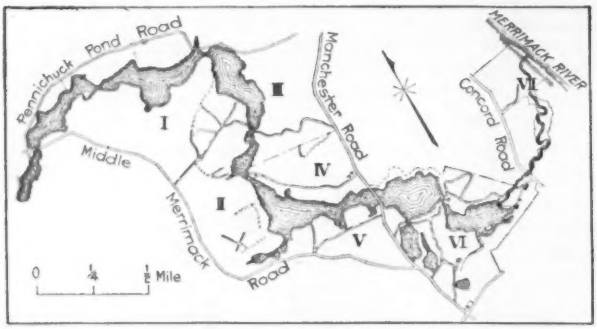


FIG. 1. MAP OF FOREST RESERVE OF PENNICHUCK WATER CO.

a self-supporting feature in water-works operation. Hence, water-works forestry that is actually yielding considerable profit and will continue to do so indefinitely is noteworthy.

As the forestry work referred to is done by a private water company operated for profit, there is no hesitancy in stating that its purpose is so to utilize the lands in the reservoir watersheds as to obtain the greatest possible financial return, although of course the protection and

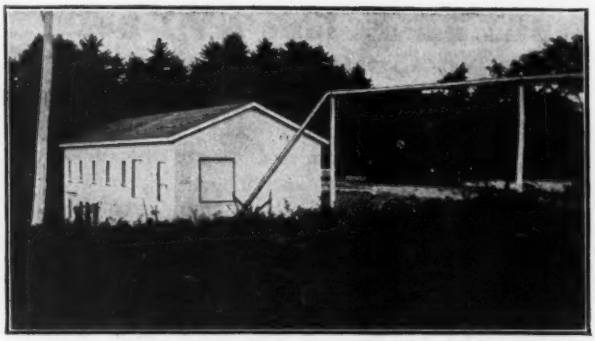


FIG. 2. SAWMILL OF PENNICHUCK WATER CO.

betterment of the watershed by means of a forest cover are considered of quite equal importance. The Pennichuck Water Co. adopted scientific forestry methods as long ago as 1907, when it employed Benton Mackaye, Forest Assistant, United States Forest Service, to make a survey of the tract and to recommend a policy of operation. But before then the company had adopted methods of conserving the timber supply.

The watershed tract, containing about 1,000 acres, is partly in Nashua and partly in Merrimack in the County of Hillsboro, N. H. (Fig. 1). About 250 acres of this is covered with a chain of ponds made by damming the Pennichuck Brook, which forms the boundary between Nashua and Merrimack. The topography is rolling, and the slopes are generally long and moderate, with many small ridges and steep depressions made from glacial drift. The greatest elevation is 220 ft. above sea level, which is about 120 ft. above the Merrimac River, which bounds the property on the east. Most of the tract is 70 to 100 ft. above the river.

The soil is sandy, chiefly of glacial origin, and covers an underlying schist rock. All this part of the country was originally well forested, and both topographic and climatic

FIG. 3. INTERIOR VIEW OF SAWMILL, PENNICHUCK WATER CO., NASHUA, N. H.

FIG. 4 FIRST SEASON'S CUT UNDER SCIENTIFIC FOREST MANAGEMENT; 1913

conditions are favorable to forest culture. The existing forests include both pine and hardwood. Much of the area was originally well stocked with large white pine, which was cut off before the land was purchased by the water company. No seed trees were left, and without proper forestry these areas grew up to small gray birch, scrub oak and other hardwoods. These and other lands which had served for pastures are being devoted to scientific raising of white pine, for which there is ever a good demand.

Acting on the advice of the forester, the company began the practice of scientific forestry by improvement cuttings, thinnings, final cuttings, planting and by ample measures for fire protection. The work is done chiefly by the company's regular employees at times when they are not engaged in other work. This permanent force is composed of 18 or 20 men with two foremen. The regular force is of course increased when new construction work is in progress. One of the two foremen has been with the company for over 30 years and is thoroughly posted on practical forestry.

During the construction season this gang lays mains and service pipes, reads and repairs meters and does the other routine of a water-works department. During the winter months the greater part of this gang, from 12 to 14, with a foreman, is sent into the woods to cut, thin and burn slash. The company's horses are also sent into the woods for hauling logs. When ready for sawing, there are taken from the permanent force in the city the sawyer, who at other times is fireman at the pumping station and general-utility man, and three other men to operate the mill. By thus furnishing all-the-year-around employment to the whole gang it is possible to hold a thoroughly experienced water-works maintenance and construction crew—and any water-works superintendent appreciates what this means in general efficiency and ease of operation.

FIG. 5. ONE OF THE FOREST FIRE PATROL MOTOR TRUCKS

The mill (Fig. 2) is placed about midway on the forest reservation, where a drop between two ponds separated by an earth embankment gives a head of 10 ft. The building is 28x70 ft., one story high with a basement. A 5-ft. penstock is laid through the embankment. A 30-in. S. Morgan-Smith wicket-gate waterwheel is installed in the basement of the building. The wheel has a capacity of 73 hp., with a speed of 165 r.p.m. using 4,300 cu.ft. of water per min., and 57 hp. using 3,400 cu.ft. The waterwheel is used to drive, by means of belts, a 1,200-r.p.m. 60-cycle 3-phase 40-kw. General Electric generator and a 3-kw. 2,100-r.p.m. 125-volt direct-current exciter. To regulate the speed of the waterwheel a Type D Woodward compensating governor is used.

The main saw, blower, etc., are driven by a 50-hp. 2,200-volt motor running at 1,200 r.p.m. A group drive system is used in which the motor is connected to a line of shafting by a flexible coupling, and this shafting drives the main saw and blower. The cutoff saw is driven by a belt-connected 5-hp. 220-volt motor. The current for the small motor is stepped down by two 2½-kw. Type H transformers. The foundations of waterwheel, governor, electrical machinery, shafting piers, etc., are all of concrete masonry.

FIG. 6. TYPICAL FOREST SCENE, PENNICHUCK WATER-SUPPLY

The sawmill is a No. 1 Lane single mill with an iron saw frame, 25-ft. log carriage having 30 ft. of feed rack and 30 chairs and rolls. The mill is equipped with a Guernsy saw guide, Fairbanks gage roll, improved spreader with steel plate, and many other uptodate devices. The main saw is a 48-in. Atkins, and the cutoff saw is a heavy "swing trimmer" 30-in. saw. The sawdust is all drawn off through a blower and discharged through a pipe, shown in the foreground of Fig. 2, to a sawdust pile some distance from the mill. The mill and all equipment are thoroughly up to date and designed as a permanent institution.

When not sawing timber, the electric power may be transmitted to one of the company's water-works pumping stations, where it is used to operate a De Laval 6-in. horizontal single-stage double-suction centrifugal pump having a capacity of 1,000,000 gal. daily. The pump is driven by a direct-connected 35-hp. 2,200-volt motor running at 3,500 r.p.m. The power line was so laid out as to be as direct as possible and yet avoid cutting any unripe timber.

Ample provision is made for forest-fire fighting. The whole water-works crew may be assembled and used for this purpose. The men are quickly summoned by tele-

phone, and three motor cars are kept in constant readiness to transport them to any part of the forest lands. Well-graded and smooth-surfaced gravel roads wind through the forests, serving both for cutoffs in case of fire and to provide access to the various forest compartments (see map, Fig. 1). The equipment of the motor cars used for fire fighting includes 16 portable fire-extinguishers, shovels, picks, etc. A team of horses and a plow are also held in readiness. There have been no serious fires on the company's lands, and most of the fire fighting has been done on neighboring property.

As may be gained from the foregoing description, the forestry end of the Pennichuck Water Co.'s business is by no means insignificant as an income producer. The approximate value of the company's standing timber at the present time is probably close to $100,000. Scientific cutting and care of the forests have been going on for years, and the average annual yield is about 250,000 ft. b.m. ($5,000 at $20 per M.). Besides this cut from the company's own lands the sawmill cuts at a profit, on an average, about an equal amount of timber for neighbors who haul their logs to the mill. Here, then, is a water-works forest that is not experimental, but is a valuable and paying asset.

Steel Car-Repair Shed with Cement-Tile Roof

A large car-repair shed built recently at Nonconnah, Tenn., by the Illinois Central R.R. is of steel-frame construction with saw-tooth roof and open sides. The building is 1,140 ft. long and 176 ft. wide. Its width is divided into four 44-ft. bays, each having two tracks spaced 22 ft. c. to c., as shown in Fig. 1.

The columns are spaced longitudinally 30 ft. c. to c. and stand on concrete pedestals. They have knee-brace connections to the trusses, except in every fifth panel, where diagonal bracing is fitted. The columns are of H-section, built up of four angles and a web plate. Those for the braced bays, with a column load of 150,000 lb., have a plate $\frac{3}{8}$x10 in. and angles 5x3$\frac{1}{2}$x$\frac{3}{8}$ in. The interior columns between these bays, with 62,500-lb. load, have angles 4x3x$\frac{5}{16}$ in., and a plate 8x$\frac{5}{16}$ in. The exterior columns between the braced bays, with 37,500-lb. load, have angles 3$\frac{1}{2}$x2$\frac{1}{2}$x$\frac{1}{4}$ in. and a plate 8x$\frac{1}{4}$ in. The knee braces are pairs of angles, and the diagonals in braced panels are pairs of angles 5x3x$\frac{3}{8}$ in., with lacing.

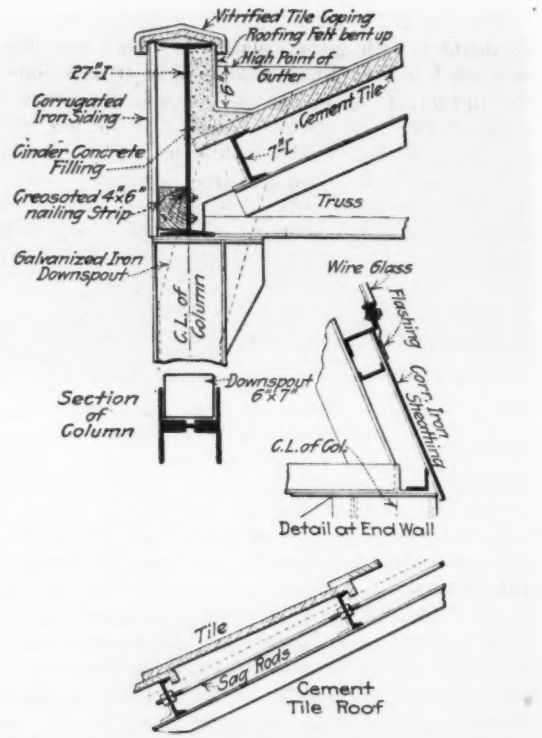


FIG. 2. DETAILS OF ROOF OF CAR-REPAIR SHED AT NONCONNAH, TENN.

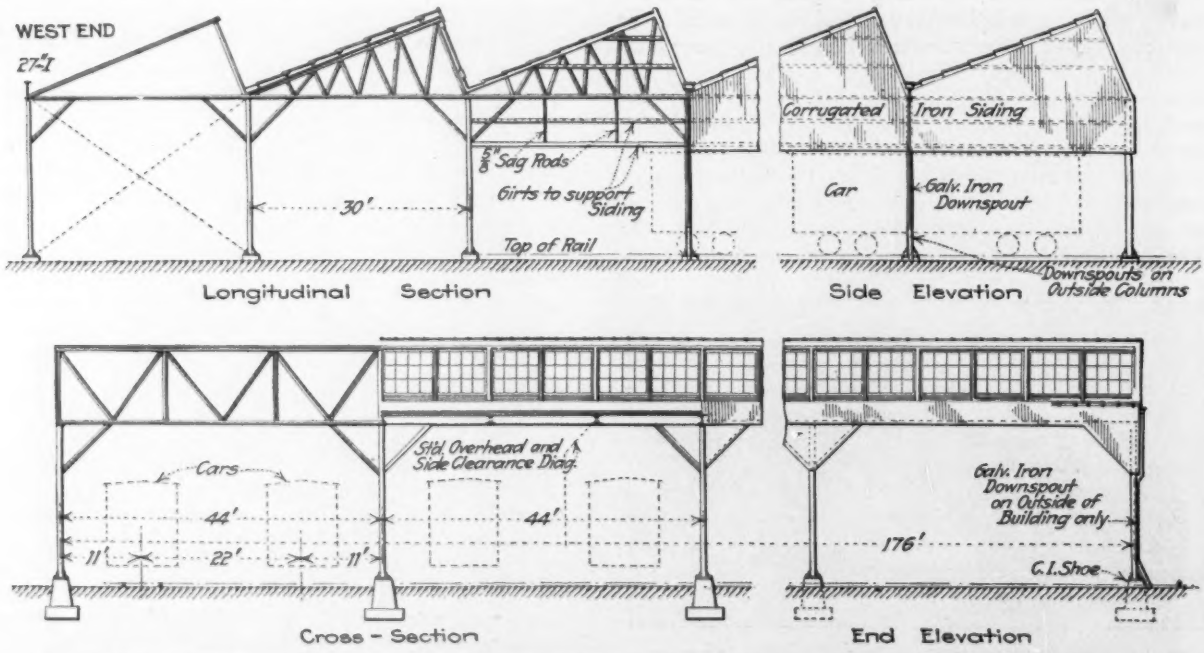


FIG. 1. STEEL-FRAME CAR-REPAIR SHED FOR ILLINOIS CENTRAL R.R. AT NONCONNAH, TENN.

The saw-tooth trusses are built up of angles (single or double) with gusset plates. In each row these are connected by two lines of transverse trusses—one along the upright faces of the trusses and the other in the plane of the inclined top chords. In the braced panels also there is horizontal crossbracing in the plane of the lower chords. There are 13 lines of these trusses, 14 ft. 8 in. c. to c., five of them being supported on the columns and the intermediate lines being carried by the transverse trusses.

On account of the climate and in order to give plenty of light and air the sides are open to a height of about 15 ft. from the ground. Above this there is corrugated-iron sheeting attached to horizontal girts or shelf angles across the outer columns and trusses. The upright fronts of the saw teeth are fitted with wire glass, while the inclined portions of the roof are covered with cement tile.

Across the top chords are laid purlins of 7-in. channels connected by tie-rods. Upon the purlins are laid the cement tiles, which are 4x2 ft., each with a lug at the upper end to hook over the purlin, while the lower end laps over the next tile. The joints are covered with tiles of inverted-trough section. The rows of tile break joints, and the middle of each tile has at its lower end a hollow rib or roll to fit over the joint tile of the course below. The gutters across the roof drain to both sides, and the outer columns have galvanized-iron downspouts, about 6x7 in., fitted between the flanges, as shown in Fig. 2.

The roof construction is of particular interest. The building was originally designed to have a composition roofing applied on 2-in. tongued-and-grooved wood sheathing. This heavy sheathing was made necessary by the wide spacing of the purlins—4½ to 5 ft. Later, the cement-tile covering was adopted, and the purlins were spaced to fit the length of the tile. Fig. 3 shows a part of the completed roof.

The cost for both designs of roof was 14c. per sq.ft., that for the original design being divided as follows: Lumber, 7c.; connections and anchoring lumber to steel purlins, 2c.; composition roof in place, 5c. The weight was 13 lb. per sq.ft. for the wood and composition roof and 15 lb. for the tile. But while the former was estimated to have a life of 10 yr., the latter was considered practically permanent.

As the permanent roof would cost no more than the other, it was adopted; but it is pointed out that the contract was placed at a time when the prices for material were very low, while the unusual extent of the work enabled a low price to be secured for the tile. For a structure of average size it is not thought probable that a tile roof could be built for the same cost as a composition roof.

The car shed was designed and built under the direction of A. S. Baldwin, Chief Engineer of the Illinois Central R.R. The contractors for the foundations and sewers were E. H. Walsh & Son, Memphis, Tenn. The steelwork was fabricated by the American Bridge Co. and erected by the Kelly-Atkinson Construction Co., of Chicago. The cement tile was supplied and placed by the Federal Cement Tile Co., of Chicago, the tiles being manufactured at Hammond, Ind. The steel sash was furnished and placed by the Trussed Concrete Steel Co., of Youngstown, Ohio, and the sheet-metal work and painting were done by Nohsey & Schwab, of Memphis, Tenn.

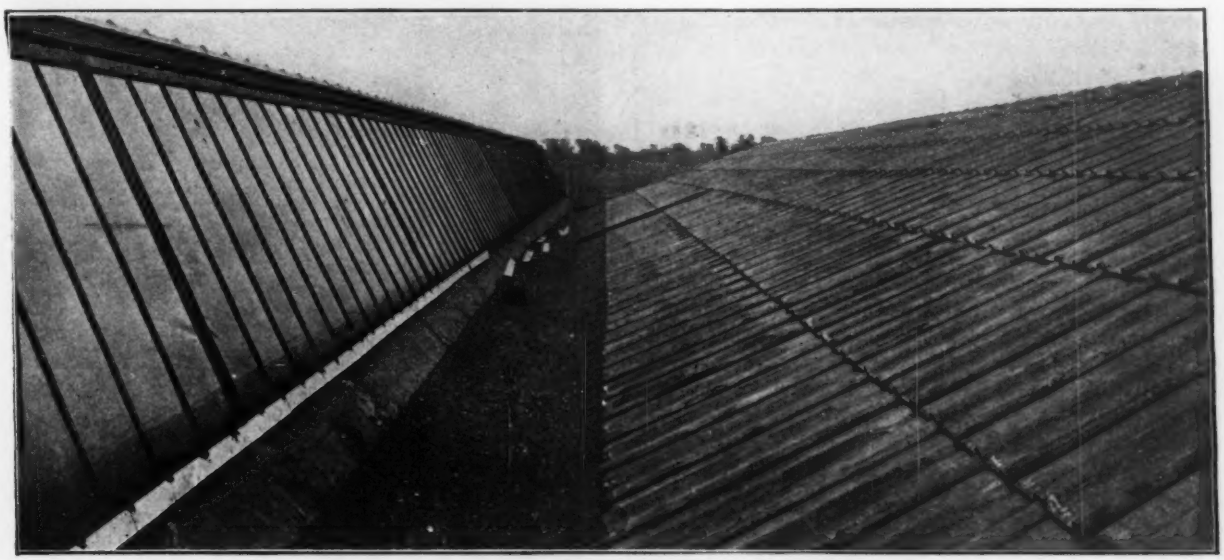


FIG. 3. SAWTOOTH ROOF WITH WIRE-GLASS FACE AND CEMENT-TILE COVERING

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The Only Electric-Car Ferry in this country is reported to be that operated by the Oakland, Antioch and Eastern Ry. across Suisun Bay. Cars with passengers are regularly carried on the gasoline-engine driven barge "Ramon." This boat is of steel, 185 ft. long and weighs 590 tons. It ordinarily carries six passenger or eight freight cars. A noticeable feature is the absence of curved plates and the adoption of a box-like design with ends that are extremely flat in order to present a large area of displacement to overcome tipping while loading or unloading cars. There are two longitudinal bulkheads and four transverse bulkheads. The pilot house is supported by steel towers at the base of which are the deck-houses. A pneumatic steering gear controls a balanced rudder on either end. There are three tracks on the main deck, each 220 ft. long, having a total capacity of nine cars. There is a catenary overhead line so that the trains are able to run off the ferry under their own power. A 600-hp. eight-cylinder 210-r.p.m. gasoline engine is set amidships and coupled through friction clutches to a propeller at either end.

News of the Engineering World

Reinforced-Concrete Wall Tips When Backing is Removed

Removal of the earth front embankment which held up a weak reservoir wall at Madison, Wis., allowed the water in the reservoir to destroy the wall by overturning it on Aug. 26. Though the wall and indeed the whole reservoir were reinforced-concrete structures, there was evident lack of tying between the parts. The wall was reinforced as a beam spanning between floor and roof, but it was not attached to the roof and therefore slipped out from under it.

On the afternoon before the accident the contractor for the extension of the reservoir removed about 12 ft. of embankment at the northwest corner of the existing reservoir. For half the length of the north wall, more or less of the embankment was dug away. The general view, Fig. 1, shows that the wall was quite free to overturn in this condition. The water flowing from the reservoir went into the pit, so that little damage was done to adjoining property.

The reservoir, built nine or ten years ago, is a roofed basin sunk half-depth below grade, in filled ground. It is about 90 ft. square and 16 ft. deep. The earth slopes down from a point about 6 ft. below the roof to street level, 4 or 5 ft. lower, on a 2:1 slope or flatter. Excavation for the extension of the reservoir, along the northerly side, was carried approximately down to the floor level.

The roof consists of a double slab—a 3-in. slab laid on top of a 4-in. slab (see Fig. 1)—carried by 8x10-in. beams, 10 to 12 ft. apart, running at right angles to the wall that failed. Concrete columns under the beams are spaced 10 or 12 ft. The wall, reinforced in its outer plane only, is about 12 in. thick at the top, 18 or 20 in. at the bottom, and contains vertical main reinforcement of $\frac{7}{8}$-in. round rods 4 in. apart, set 2 in. in from the outside. There is horizontal secondary reinforcement of $\frac{3}{4}$-in. rounds spaced 12 in. apart, whose effect

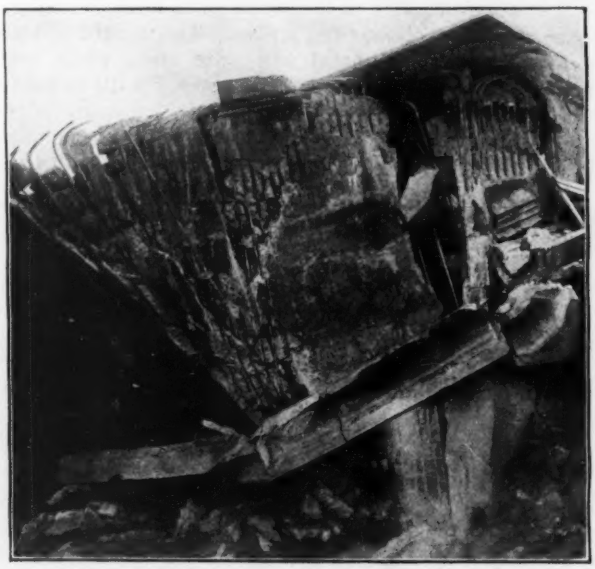


FIG. 2. HOW THE WALL TORE AWAY AT THE CORNER

shows in the way the wall hangs together and in the nature of the cracking.

Tie steel between wall and roof seems to be absent. The bent-over rod-ends in the views evidently were merely bent out of the way because too long. There is a con-

FIG. 1. OVERTURNED RESERVOIR WALL AT MADISON

The horizontal steel was mostly cut after the collapse, to permit entrance. Arrow at right shows point from which Fig. 2 was taken

FIG. 3. VIEW ALONG FAILED WALL

struction joint about 18 in. below top of wall, with sandier looking concrete above than below.

The city officials have not made a statement concerning the accident. The water-supply is critically affected because the city's storage is eliminated and water is being pumped directly into the mains.

Water Company Makes Its Own Alum and Chlorine

Plants for making filter alum from bauxite and chlorine gas from brine are being built by the Montreal Water and Power Co., under the direction of J. O. Meadows, engineer and superintendent of the company's water-filtration plant. Both plants will be in use about Nov. 1.

The filter alum or sulphate of alumina plant will have a capacity of five tons a day, and will make use of the process worked out by Charles P. Hoover, chemist and superintendent of the filtration works of Columbus, Ohio. Bauxite, ground and bagged, will be bought from the Aluminum Company of America, one of the many companies supplying that material. Under normal conditions the proposed plant would save $8 per ton on the sulphate of alumina used, but at the present prices of chemicals the saving will be five times that. In other words, sulphate of alumina now costs $70 per ton and can be made at the Montreal filter plant for $30 a ton. The material has already been produced in a crude way by the company, and used with satisfaction.

Chlorine gas will be made in four Moore-Allen cells having a capacity of 120 lb. of gas per day. From the tanks, which are being cast at the plant from crushed and powdered stone and cement, the gas will pass through silver injectors, then be mixed with water and applied to the water to be heated through distributors. The plant will be able to treat 30,000,000 gal. (Imp.) a day. Besides effecting a considerable saving over the present market price of chloride of lime, and a slight saving under normal conditions, the new plant will have the advantage of greater simplicity, will avoid the nuisance due to handling hypochlorite and will save general depreciation around the adjacent parts of the works due to the use of hypochlorite.

State To Vote for Bridge or Tunnel at New Orleans

The Louisiana Legislature at its recent sessions passed a joint resolution authorizing a constitutional amendment to provide for the construction of a bridge or tunnel across the Mississippi River at or near New Orleans. This amendment is to be voted on by the electorate of Louisiana on Nov. 7, and it is expected that it will be passed with little opposition. The responsibility for planning and constructing the new bridge or tunnel has been placed upon the Public Belt Railroad Commission of New Orleans, which body has created a special committee on "Bridge or Tunnels" to study the situation. This committee has already held hearings at which prominent engineers have given their opinions, and the committee informs us that it is desirous of hearing from other engineering firms who may wish to apply for contracts in connection with the work.

City Provides Elevated Street To Retain Industrial Plant

The City of St. Paul, Minn., has just vacated about 300 lin.ft. of a city street and elevated the grade so that traffic can be carried on a viaduct in order to retain an industrial plant which otherwise threatened to move away.

The H. Koppers Co. had purchased 38 acres of land from the Northern Pacific Railway Co. for a coke plant. As the plant required a long, unbroken site, the company asked the city to vacate what claim the city might have in an old, unopened county road known as the continuation of Hamline Ave. While desirous of retaining the Koppers Co., the city felt that its rights to Hamline Ave. should not be given up, as it was developing into an arterial street in other parts of the city. The company asked for the vacation of the street in order that it might have full possession and offered to build and extend the present footbridge over the Great Northern Ry. tracks across its property some 300 ft., or would permit the city to reserve the right in the vacation proceedings to build piers to support a viaduct. The corporation counsel ruled that if the city vacated the street it would have no right to order the construction of a viaduct across what would then be private property, so that the reservation of rights to build piers would be valueless.

The problem was solved by establishing an air-line street or a new grade line 22.4 ft. above the present grade and vacating the street to this height. By so doing the city gives up its right to order this portion of the viaduct built at the expense of the property owners underneath, excepting that they might be assessed for benefits.

The city could have compelled the Northern Pacific Ry., former owner of the land, to pay the cost of a viaduct when such a structure became a necessity. It can now

compel the railway companies on either side of this vacated portion to pay the cost of a viaduct over their lands, but this viaduct, 303 ft. in length, will have to be paid for out of the general fund of the city or assessed against the district benefited, and the railways could not be assessed any part of this on account of paying a gross-earnings tax.

Dexter Brackett Medal

The bronze medal of the New England Water-Works Association, struck in commemoration of the life and work of Dexter Brackett, for many years chief engineer of the Metropolitan Water and Sewerage Board of Boston, Mass., is illustrated herewith. The resolution to honor the memory of Dexter Brackett, past-president of the

association, was adopted by the committee in a meeting at Boston, Nov. 10, 1915. Enough members immediately guaranteed a sufficient fund to assure the success of the plan, and later the entire membership was given an opportunity to contribute. The total sum raised was $1,286.

The designer of the Dexter Brackett medal is T. Spicer-Simson, of New York City. The committee of the association in charge consisted of Frederick P. Stearns, chairman; Allen Hazen; Alfred D. Flinn; George A. Stacy; Charles W. Sherman, secretary and treasurer. The committee suggests that the first award be made for the calendar year 1916, so that all papers published in the *Journal* of the association for the present year will be considered. The first presentation of the medal will then take place at the 1917 annual convention.

Philadelphia Has Record Water Consumption

The greatest water consumption in one week in the history of Philadelphia occurred in the week of Aug. 20. Approximately 2,338,000,000 gal. were used, an average of 334,000,000 gal. daily. The highest previous week's averages were as follows: 1915, average daily consumption, 320,000,000 gal.; 1914, 310,000,000 gal., and 1913, 316,000,000 gal. The daily per capita consumption in Philadelphia is about 180 gal.

The city is threatened with a water famine. The filtration plant, which cost the city $35,000,000 is inadequate and Carleton E. Davis, Chief of the Bureau of Water, is preaching economy in the use of water. In many buildings and houses, especially in South Philadelphia, there is no water for hours daily. Water Bureau officials say the pressure should reach between 30 and 40 lb., while fire underwriters insist that it shall be 60 lb. Two plans to relieve the condition are being considered by city officials. One is securing money for the construction of an additional pumping station and a filter bed with a capacity of 100,000,000 gal. daily, and for the building of a large express main from Torresdale (the head of the supply) to South Philadelphia. The other method is the long-agitated proposition to place water meters over the entire city.

Ontario Hydro-Electric Power System To Be Enlarged

Owing to the rapid increase in the consumption of electric power the Ontario Hydro-Electric Commission has decided to proceed immediately with plans for the extension of the provincial power-transmission system, which it was intended to postpone until after the war. Sir Adam Beck, Chairman of the Commission, announces that the plants in Toronto and Dundas will be doubled and the transmission line between these points duplicated involving an expenditure of over $1,250,000. Preliminary work on the stations is already under way and plans and specifications for the new transmission line have been completed. At Niagara Falls new switches and other equipment to handle the additional 50,000 hp. being secured from the Canadian Niagara Power Co. are being installed. The maximum load of Niagara power now ranges between 115,000 and 120,000 hp. These extensions will insure an ample supply for the needs of Toronto and bring the equipment at Niagara Falls and Dundas up to the condition necessary to handle the larger load which will be available at the end of the year.

The Commission has also decided to proceed immediately with the work of linking up the four power plants at Eugenia Falls, Big Chute, Wasdell Falls and Swift Current, in the Owen Sound-Collingwood district. This will require the construction of 41 miles of transmission lines. It will give a total supply from these four developments of 15,000 hp. With the increased production possible at the Big Chute and developments yet to be made on the Saugeen and Severn Rivers the ultimate development of this district will be 25,000 hp. As the Northern line will be only six miles distant from the Niagara power transmission line at Mount Forest, the two systems can easily be linked together if thought requisite in the future. Sir Adam Beck states that new municipalities are being connected with the system and that the steady increase in consumption is largely due to the manufacture of war munitions.

Birmingham, Ala., Water-Works Purchase—Negotiations have been begun by the Board of Commissioners of Birmingham, Ala., and A. M. Lynn, president of the Birmingham Water Co., relative to the purchase of the water-works. Under the franchise of the company, the city may purchase the plant by giving adequate notice, which has already been done. Efforts are being made to arrive at a suitable price, and if this fails arbitrators will be chosen.

Water Company Not Compelled To Test Wells—The chancery court at Little Rock, Ark., decided that it was unnecessary for the Arkansas Water Co. to have its new auxiliary well system tested by other than its own engineers to show whether it had complied with the city's orders. The city of Little Rock sued for an order compelling the company to have the test made by disinterested engineers. The company objected on the ground of expense. The wells have an alleged pumping capacity of more than 6,000,000 gal. per day.

State Highway Commission for Georgia—The Georgia Legislature has passed a bill providing for the creation of a State Highway Commission. This is to consist of the members of the State Prison Commission, the state geologist, and the professors of highway engineering at the Georgia School of Technology and the State University. There is no provision for a state highway engineer other than the engineers that may be employed by the prison commission. One section of the law states that this commission shall be empowered to receive funds from the Federal Government for road purposes.

Tidal Flow Affects Artesian Wells near the ocean, according to a report of the United States Geological Survey. In studying wells in the coastal plain of Virginia it was found that there was a decided variation in the well flow with the rise and fall of the tide, the flow being notably greater at the flood than at the ebb tide. It is the general opinion among well drillers that practically all flowing wells near tidal rivers or inlets from open bays do feel the distant sea, but some of them so slightly that the variation in flow is not noticeable. The geologist in charge of the groundwater investigations in Virginia states that changes in water level in wells, due to fluctuations in the height of the surface of some neighboring body of water, have been observed all over the world. It is customary to explain these changes by supposing a direct connection between the river, lake, or bay; but in many places, as in eastern Virginia, such connection is clearly impossible, owing to the depth of the wells and the nature of the intervening beds, some of them dense, tough marls and clays. These beds, however, though they do not transmit water, nevertheless contain it, and as water is practically incompressible, any variation of level on the river or bay is transmitted to the well through the water-filled gravels, sands, clays and marls. When a porous bed is tapped by a well the water rises to the point of equilibrium and fluctuates as the hand of the ocean varies its pressure on the beds that confine the artesian flow.

PERSONALS

Ross Miller has been appointed Engineer of the South Dakota Railroad Commission to succeed Joseph E. Love, resigned.

A. M. Frink, architect and engineer, 723 Illuminating Bldg., Cleveland, Ohio, announces that he has taken over the business formerly conducted by Izant & Frink.

James W. Moore, recently Engineer of the New Orleans United Gas and Electrical Engineering Corporation, has been appointed Chief Engineer of the Van Kuren Engineering Co., Birmingham, Ala.

H. S. Riddle, M. Am. Soc. M. E., Consulting Engineer of the Ohio Board of Administration, Columbus, Ohio, will resign Oct. 1 to accept a position with the Jeffrey Manufacturing Co., also of Columbus.

Alfred F. Townsend, for the past seven years manager of Woonsocket (R. I.) Electric Machine and Power Co., has been appointed Local Manager of the Stone & Webster properties in Beaumont and Port Arthur, Tex.

Frank H. Olmstead, M. Am. Soc. C. E., of Olmstead & Gillelen, Consulting Engineers, Los Angeles, Calif., has been appointed Engineer in Charge of flood-protection plans for the Gila River, by Secretary Lane, of the United States Department of the Interior.

Francis M. Veatch, Jun. Am. Soc. C. E., recently appointed Assistant Engineer of the Kansas State Board of Health, has resigned, effective Oct. 1, to become Superintendent of the East St. Louis, Ill., water-purification plant of the American Water-Works and Electric Co.

J. T. Bullen, M. Am. Soc. C. E., has resigned as Parish Engineer, Caddo Parish, Louisiana, to become Highway Engineer of several road districts in Raleigh County, West Virginia, the aggregate funds of which are $850,000. He was formerly Senior Engineer, United States Office of Public Roads and Rural Engineering.

E. L. Brown, Vice-President and General Manager of the Denver & Rio Grande R.R., Denver, Colo., has been elected President of the Minneapolis & St. Louis R.R., succeeding Newman Erb, resigned. Mr. Brown is 52 years old and entered the railway service as a telegraph operator. For several years previous to 1912 he was an operating official of the Northern Pacific and Great Northern railways.

J. H. Nuelle, Assistant General Superintendent and Chief Engineer of the New York, Ontario & Western Ry., has been promoted to be General Superintendent, with headquarters at Middletown, N. Y., succeeding the late Edward Canfield. Mr. Nuelle is a graduate of Princeton University, class of 1906, and until June, 1907, was a transitman with the Pennsylvania and New York Central lines. He entered the service of the New York, Ontario & Western Ry. as an assistant engineer. In 1911 he was made Principal Assistant Engineer and in 1912, Engineer of Maintenance-of-Way.

The Universal Portland Cement Co., Chicago, Ill., announces the following promotions and changes in its engineering staff: **Adolph G. Carlson** is appointed Chief Engineer. He was formerly Assistant Superintendent of the Syracuse, Ind., plant of the Sandusky Portland Cement Co. He has had to do with the designing of Nos. 3, 4 and 6 mills of the Universal Portland Cement Co., at Buffington, Ind., and No. 5 mill at Pittsburgh and No. 7 mill at Duluth. He was appointed Mechanical Engineer in 1907. **M. S. Humphreys,** formerly Superintendent, Mill No. 6, Buffington, Ind., plant of the Universal Portland Cement Co., is appointed Assistant Mechanical Engineer at the general offices in Chicago. **Nels Nelson,** formerly Superintendent of Mill No. 2, at South Chicago, which plant has been dismantled, is appointed Superintendent Mill No. 6, Buffington, Ind., plant. **J. H. Lendi** is appointed Electrical Engineer at the general offices in Chicago. Mr. Lendi has been connected with the company for several years in the engineering department.

ENGINEERING SOCIETIES

AMERICAN FOUNDRYMEN'S ASSOCIATION.
Week of Sept. 11. Annual meeting in Cleveland, Ohio. Secy., A. O. Backert, 12th and Chestnut St., Cleveland, Ohio.

AMERICAN INSTITUTE OF METALS.
Week of Sept. 11. Meeting in Cleveland, Ohio. Secy., W. M. Corse, 106 Morris Ave., Buffalo, N. Y.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS.
Sept. 11-16. Convention, Minneapolis, Minn. Secy., Fred W. Raven, 417 S. Dearborn St., Chicago.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 12. Convention in Atlantic City. Secy., A. P. Dane, Reading, Mass.

RAILWAY SIGNAL ASSOCIATION.
Sept. 12-14. Convention in Mackinac Island. Secy., C. C. Rosenburg, Myers Building, Bethlehem, Penn.

NEW YORK STATE ASSOCIATION OF COUNTY SUPERINTENDENTS OF HIGHWAYS.
Sept. 13-14. Meeting at Syracuse. George S. Tibbits, Chairman of Executive Committee, Onelda, N. Y.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 13-15. Convention in Portland, Me. Secy., Willard Kent, Narragansett Pier, R. I.

ILLUMINATING ENGINEERING SOCIETY.
Sept. 18-20. Convention in Philadelphia, Penn. Asst. Secy., C. D. Fawcett, 29 West 39th St., New York, N. Y.

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS.
Sept. 18-22. Convention in Chicago. Secy., W. O. Oschmann, Oliver Iron and Steel Co., Pittsburgh, Penn.

ROADMASTERS AND MAINTENANCE OF WAY ASSOCIATION OF AMERICA.
Sept. 19-22. Convention in New York City. Secy., P. J. McAndrews.

AMERICAN PEAT SOCIETY.
Sept. 21-23. Annual meeting in Washington, D. C. Secy., Julius Bordollo, Kingsbridge, N. Y.

AMERICAN CHEMICAL SOCIETY.
Sept. 25-30. Annual meeting in New York City. Secy., Charles L. Parsons, Washington, D. C.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 9-13. Convention in Newark, N. J. Secy., Charles C. Brown, Indianapolis, Ind.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.
Oct. 9-13. Convention at Atlantic City, N. J. Secy., E. B. Burritt, 8 West 40th St., New York City.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 17-19. Convention in New Orleans. Secy., C. A. Lichty, C. & N. W. Ry., Chicago.

AMERICAN GAS INSTITUTE.
Oct. 17-20. Annual meeting in Chicago. Secy., G. G. Ramsdell, New York, N. Y.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 24-27. Convention in Cincinnati, Ohio. Secy., Prof. Selskar M. Gunn, Boston, Mass.

RAILWAY ELECTRIC SUPPLY MANUFACTURERS' ASSOCIATION.
Oct. 30-Nov. 3. Annual meeting at Chicago. Secy., J. Scribner, General Electric Co., Chicago.

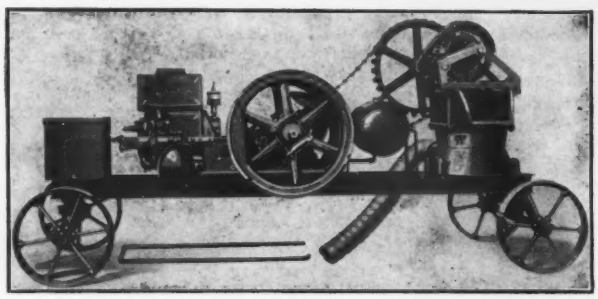
NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 14. Convention in Washington, D. C. Secy., W. H. Connolly, Washington.

RAILWAY GARDENING ASSOCIATION.
Dec. 5-7. Annual meeting in New Orleans. Secy., Charles E. Lowe, Sewickly, Penn.

Appliances and Materials

Chain-Driven Trench Pump

The power-operated trench pump shown herewith has a sprocket-chain drive from the engine to the pump, and the pump rod is driven fron an eccentric instead of from a rocker arm. The eccentric shaft is connected to the sprocket wheel shaft by a single set of gears, and a compensating link attached to the connection of the eccentric with the pump rod maintains the rod in a vertical position during its travel. The pump has a 3-in. suction at the side, and a side discharge spout to which a trough or chute can be attached. All the valves have openings sufficient to pass anything that goes through the suction hose. The outfit as shown has a pump and 2-hp. gasoline engine mounted on a steel-frame truck, the total weight being about 680 lb. If mounted on skids the weight is about 525 lb. When run at 45 strokes per



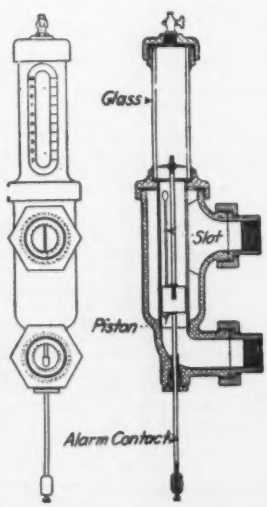
TRENCH PUMP WITH CHAIN DRIVE

min. the capacity is 3,500 to 4,000 gal. per min., but this may be doubled by an outfit having two pumps and a 3½-hp. engine, with a weight of 1,250 lb. complete. These trench pumping outfits (as well as the gasoline engines used) are built by the Waterloo Cement Machinery Corporation, of Waterloo, Iowa.

* * *

Variable-Slot Flow Meter

A new meter for indicating flow of liquids in pipes, but embodying a principle which has been similarly employed before, is shown in the accompanying sketch. It was designed by J. F. Vaughan and is being made by the Spray Engineering Co., of Boston. The liquid flows into a slotted cylinder surrounded by an annular chamber connected to the meter discharge. In the cylinder is a floating piston uncovering more and more of the measuring slot as the pressure difference increases between inlet and outlet. Piston movement is communicated to a pointer in a closed glass chamber, the walls of which are graduated. Calibration is claimed to give a uniform flow scale for all positions of the piston and pointer, within the range of the meter. The head loss is stated to be 0.004 lb. per sq. in. for 15 gal. per min. flow. An insulated brass rod rises through a packing gland in the inlet chamber and makes contact for sounding an alarm on return of the piston to any desired minimum-flow point.

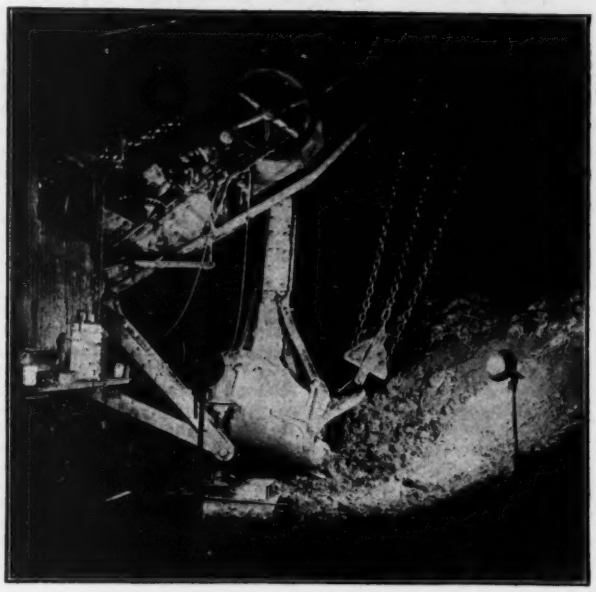


VAUGHAN METER

* * *

A 3,000-Cp. Light for Night Construction Work

The standard "No. 2" acetylene projecting lamp (nominal rating 5,000 cp.) of the Alexander Milburn Co., of 14 Baltimore St., Baltimore, Md., has been redesigned (fitted with new burner and 12-in. reflector) to make a 3,000-cp. light which will run for 12 hr., at a total charging cost of 34c. The charge consists of 9 lb. of ordinary commercial carbide. The body of the lamp is 10 in. square. The total height is 5 ft. It weighs 130 lb. charged and 58 lb. empty, and costs $42.50.



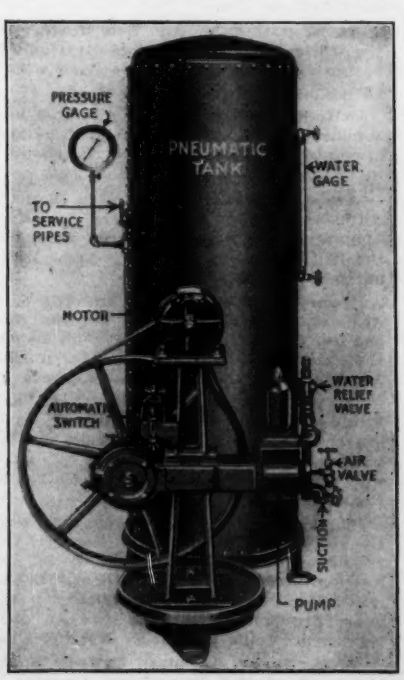
MILBURN NO. 2 AT DALLAS

The accompanying view shows a night grading operation for the new railroad terminal at Dallas, Tex., for which J. W. Thompson was contractor for the excavation which aggregated 760,000 cu.yd. It is claimed that with two steam shovels Mr. Thompson moved 1,800 yd. per night.

* * *

Electro-Pneumatic Water-Supply Outfit

A water service system for isolated residences and small plants or institutions with no water-works connections consists of a pump and pneumatic pressure tank. The pump has a horizontal double-acting cylinder, with air chamber. It is operated by a crank shaft geared to the shaft of a flywheel belted to an electric motor placed above it on top of a standard. The crank case is inclosed and forms an oil bath. The pump delivers both water and air to a cylindrical tank, about one-third of the tank space being filled with air. This tank is designed for 125 lb. pressure. When the air pressure reaches 40 lb. the motor is stopped by an automatic switch, and this again starts the motor when the pressure falls to 25 lb. The equipment includes an air inlet valve and water relief valve. When the supply is taken from a well or spring, a special attachment can be added by which drinking water may be delivered directly from the pump to a tap indoors. The outfit is built with pumping capacity of 180 and 300 gal. per hr. The larger size has a ¼-hp. motor, running at 1,150 r.p.m., 1-in. supply and discharge pipes and a 140-gal. tank. It is 6½ ft. high over all and occupies a floor space 37x44 in. (exclusive of tank). These outfits are built by the Hill Pump Co., of Anderson, Ind.



PUMP AND TANK UNIT